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The Savonius Rotor

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May 1931

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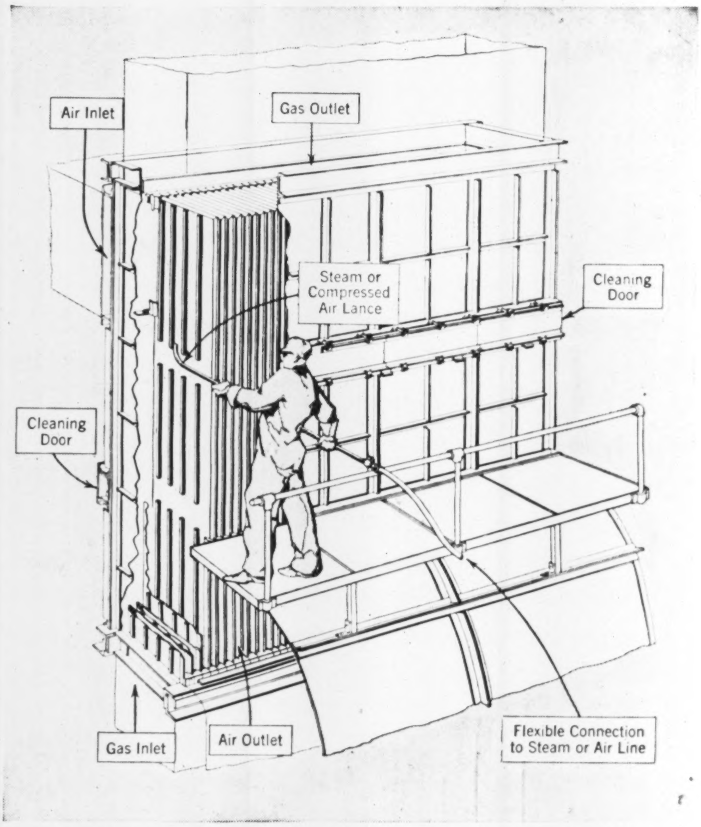
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What It's All About

THE S-ROTOR, so called because its two vanes present an S-shaped cross-section, is an odd-looking motor that is operated by air or water currents. The more familiar Flettner rotor, it will be remembered, is a slender vertical cylinder rotated by means of a low-powered motor. In a flow of air such a rotating cylinder produces the so-called Magnus effect—a difference of pressure on opposite sides of the cylinder that supplies a propulsive force when the cylinder is erected on a ship. The S-Rotor, described in the May issue of MECHANICAL ENGINEERING by its Finnish inventor, Dr. Savonius, was developed so that the rotor can be turned by the wind without the aid of auxiliary power, and thus it may be used as a windmill or aeromotor. The device is said to have an efficiency higher than that of other wind-driven motors. It is intended for uses where modest power requirements must be met with small expense.

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HYBRID POPLAR TREES FOR PULPWOOD SUPPLY are being developed to such an extent that their growth is more than ten times as rapid as normal. The experimentation carried on in this field is described by R. H. McKee in the May issue of MECHANICAL ENGINEERING. The principal requirements for rapid growth are plenty of water and sunlight, and where these may be found it is apparent that permanent groves may be established from which a continuous and profitable supply of pulpwood may be expected.

:: :: ::

REMOTE CONTROL OF A TRANSPORTATION SYSTEM in a limestone quarry serving a portland-cement plant is described by R. F. Emerson in the May issue of MECHANICAL ENGINEERING. The motor-driven cars run on a track that is energized in sections from a single control house, where an operator causes four cars to start and stop and to move to and fro individually over a mile of track between quarry and crusher house.

:: :: ::

THE COTTONSEED-OIL INDUSTRY represents an invested capital of about 200 million dollars, with products valued at 250 million dollars per year. Mechanical engineers generally have heard little about this industry. E. L. Carpenter and Leo Holdredge discuss its history, economics, processes, and problems in the May issue of MECHANICAL ENGINEERING.

ROBERT FULTON'S PATENT DRAWINGS were made before the days of blueprints. A set of them was recently discovered in the offices of *The Engineer*, in London, and through the generosity of the owners were sent to this country as a gift to the A.S.M.E. The only other set known to have existed in America (three sets are extant) was destroyed by fire many years ago. The history of these drawings is told in the May MECHANICAL ENGINEERING by the distinguished British engineer-historian, H. W. Dickinson, honorary secretary of The Newcomen Society for the Study of the History of Engineering and Technology.

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THE MAINTENANCE OF AN INDUSTRIAL ILLUMINATION SYSTEM has been studied by R. C. Smith in a paper to be found in the May issue of MECHANICAL ENGINEERING. Mr. Smith reports that lamps exposed to heavy fumes and dust should be cleaned every two months, those exposed to light dust every three months, and those exposed to very little dust every four months. In no case did he find marked advantage in more frequent cleaning of the lamps.

:: :: ::

TRENDS IN THE COTTON TEXTILE INDUSTRY, particularly in the South, are noted by C. L. Emerson in the May issue of MECHANICAL ENGINEERING. Of particular significance is the changed attitude toward living and working conditions as expressed in mill and village architecture and environment.

:: :: ::

THE MEASUREMENT OF SOUND has been undertaken by a research committee of the A.S.M.E. An abstract of the Committee's latest report, printed in the May MECHANICAL ENGINEERING, establishes the scientific basis of that body's problems.

:: :: ::

THE STAGGER-DECALAGE BIPLANE, which has adjustable wings and may be landed safely without the manipulation of the controls, is described by its inventor, Albert A. Merrill, in the May MECHANICAL ENGINEERING. While other designers have been attempting to secure safety in landing at low speeds, Mr. Merrill has developed a machine that may be safely landed at high speed, when it is less easily influenced by air currents, and that will not nose dive, spin, or stall.

MECHANICAL ENGINEERING

Volume 53 May, 1931 No. 5

The S-Rotor and Its Applications

A Bi-Vane Power Wheel of S-Shaped Cross-Section Working in Wind or Water, and Its Application in Pumping, Electric-Current Generation, and Ventilation, and as a Current and Wave Motor Where Moderate Amounts of Power Are Required

By S. J. Savonius,[1] Helsingfors, Finland

WHOEVER undertakes a study of the wind and the forces of the air in motion, encounters problems distinct from all others and replete with complications. The difficulties arising are further aggravated when he must consider and study these forces as a source of power and reduce the vague and apparently aimless vacillations of the air to a really scientific and dependable basis.

The whole history of the use of wind power bears witness to these facts, and it is only in comparatively recent times that the development of aerodynamic science and modern wind-tunnel research methods have provided more dependable means of attacking and solving these problems. In spite of this, there are still many questions on which even scientifically trained investigators come to different conclusions, and as the S-rotor and its development present an apt illustration of such a case, and at the same time throw some interesting side lights on aerodynamic questions of recent years, an account of the nature and practical applications of this new type of airflow turbine may be of interest.

Any one conversant with the literature covering the use of wind power has not failed to note that earlier investigators, constructors of windmills, and manufacturers of aeromotors had very hazy and usually exaggerated ideas as to the amount of power that could be got out of the wind. In some of the prewar literature and in the catalogs and leaflets of aeroturbine and windmill manufacturers, we often find power outputs given which exceed by far the theoretical power of the wind at the stated speed.

The highest actual power output reached with streamline propeller wheels of modern design seems to be about 40 per cent of the total power latent in the wind. This value has been arrived at by very painstaking tests with scale models in the wind tunnel at Göttingen. The highest value reached with multi-vaned wheels is around 30–32 per cent, though the percentage may be very much lower for badly designed wheels of this type. The average multi-vaned steel windmill rarely exceeds 15–20 per cent in power output, while the older types with plane vanes or wood slats hardly came up to 10 per cent. The now classical 4-vaned windmill type developed by Professor La Cour gives an output of 21 per cent, this value having been fixed by several independent investigators.

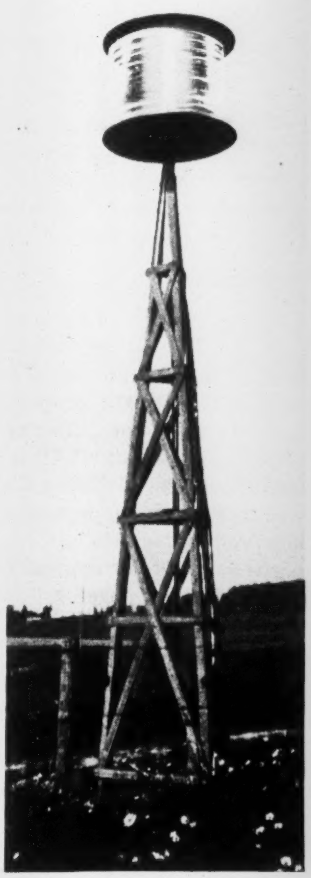

Fig. 1 S-Rotor of 1 Square Meter Area Used in the Pumping Trials

The foregoing applies to tests carried out in a wind tunnel, where the wind is steady, but conditions in natural wind are so different that the question arises whether the results obtained therein may not be different from those arrived at in wind-tunnel tests. We may, however, not be far from the facts if we assume that the power of an aeroturbine working in natural wind is about one-tenth to one-eighth greater than it is in a wind tunnel.

On the other hand, tests in natural wind do not bear out this supposition; in reality, facts point in a contrary direction. It is easy to understand that a windmill which has to adjust its position to the wind with the aid of a tail vane or other device cannot instantly follow

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[1] Savonius & Company.

For presentation at the Fifth National Meeting of the A.S.M.E. Aeronautic Division, Baltimore, Md., May 12 to 14, 1931.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

the frequent changes in wind direction and in consequence must lose power. It has also been shown by Bilau and others that losses due to turbulence and head resistance in the unsteady natural wind are about 1.6 times greater than in a wind tunnel. The gain due to the greater relative power value of the natural wind is again more than lost through the causes described.

All that has hitherto been brought forward refers to the common type of windmill or aeroturbine, working on a horizontal axis, with the wheel plane vertical and normally at 90 deg. to the wind direction. This type is usually called the horizontal type, as distinguished from another type called the vertical airwheel or turbine, working on a vertical axis, the turbine or rotor moving in a horizontal plane or in a direction parallel to the wind.

Professor Betz has calculated the magnitude of the power output of the vertical type of airwheel and finds 20 per cent as the theoretical maximum, or one-third that of a horizontal wheel of equal wind area. In this 20 per cent all losses are disregarded, and as they are considered to be much greater for the vertical airwheel than for the other type, no authority on wind power is willing to grant the vertical airwheel a higher practical output than 10 per cent, and even this value is regarded as very problematic, and usually is reduced to 5 per cent.

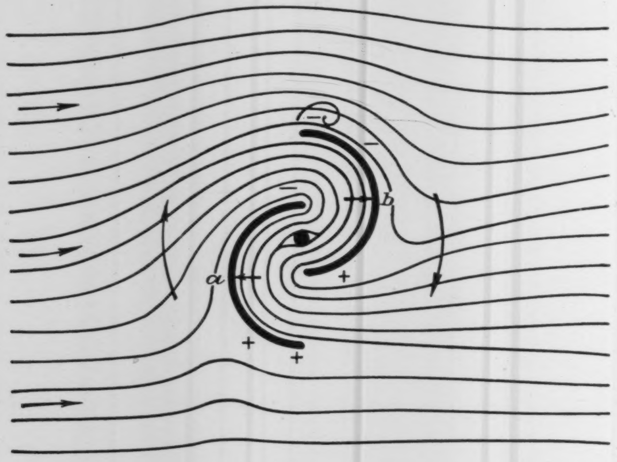

Fig. 2 Air Streaming and Pressure Differences Around an S-Rotor

(Note the flow through the central air passage, the smooth streaming, and the absence of a vacuum at the back of the advancing vane.)

The Author's First Experiments

The author's interest in aerodynamic problems was roused by the Flettner rotor ship in the fall of 1924. Like so many others, he asked himself if it were not possible to substitute wind power for the external motor power needed to turn the cylinder rotors. He could not resist the temptation to make a small experiment and, going about it in the simplest possible way, cut a Flettner cylinder from top to bottom into two semi-cylindrical surfaces, moved these sideways along the cutting plane, forming a "rotor" which in cross-section resembled the letter "S," placed a shaft in the center and closed in the surfaces between two circular endplates.

Testing this model on a windy day an unmistakable pull manifested itself which tended to press the shaft sideways. The next step was to make another similar structure and to mount both on the ends of a common shaft, to the middle of which was fixed another shaft at right angles.

This gave something resembling a two-bladed propeller or windmill, with S-rotors instead of ordinary vanes. Holding this structure in the wind, not only did the rotors spin round but the whole propeller revolved at a fair rate, and the fact that a structure quite unlike the original cylindrical rotor could develop that mysterious Magnus force or side pressure, and also that no power except that of the wind was needed for this, was established. It seemed natural to assume that the magnitude of the side pressure was dependent on the rotary speed, increasing with it, and the next question was how to increase the speed of the rotor. By moving the half-cylinders slightly back toward each other and the central axis, leaving a gap or air passage in the middle of the rotor as shown in Fig. 2, it was found that the wind striking the cup of one vane would flow through the central gap into the other vane, replacing with pressure there the vacuum which caused the drag. This new rotor revolved much more rapidly, and there was a decided increase in the side pressure also.

Applying the new device to the same purpose that Flettner had applied the revolving cylinders, a 15-ft. sloop was equipped with two metal S-rotors of about 20 sq. ft. area each. The vanes were reversible, so as to allow sailing with wind from either side. In a favorable breeze a speed of 6 knots was reached. The boat beat against the wind, and sailed in all directions.

The next application to undergo tests was a rotor of 2 square meters area (21.4 sq. ft.) for pumping water. The results obtained were very encouraging; comparing the output with that of a 6-ft. windmill of American manufacture, the S-rotor, area for area, seemed to be about 70 per cent better.

Recognizing now the need of a more scientific mode of procedure to determine the best vane form for the new rotor and to study the influence of size and shape of central opening, endplates, and other details on the speed and power output, and also to fix this output as carefully as possible, the author redesigned and enlarged the wind tunnel he had formerly used and equipped it with the necessary recording instruments, brake-test appliances, etc. To avoid inaccuracies due to very small values, the test models were made comparatively large, with a wind area of 2300 sq. cm. (about $2^1/_2$ sq. ft.). In all some 50 different models were made and tested in the wind tunnel. These models included several aeroturbines and windmills of the ordinary horizontal type, several models of vertical airwheels of older constructions, and finally more than 30 different models of the S-rotor, varying in vane form, size of central air passage, and other details.

Results of Comparative Power Tests

The power percentages obtained with the ordinary types of horizontal airwheels were practically the same as the corresponding values found by other investigators in wind-tunnel tests. So, for instance, with the La Cour wheel the author got an output of 20–22 per cent and an optimum *u/v* ratio of vane-tip speed to wind speed of 2.25. The corresponding values in tests made in the Göttingen wind tunnel gave 21 per cent and a *u/v* ratio of 2.3.

With the best of the multi-vaned wheels of horizontal type, a scale model of a well-known aeroturbine of German make, an output of 32.5 per cent and a corresponding *u/v* ratio of 1.25 were obtained. This latter had 12 carefully curved vanes, and the output may be regarded as extremely good for this type of wheel.

With multi-vaned turbines of the vertical type the best result obtained was 14 per cent, and this with a 3-vaned wheel very closely resembling the S-rotor, but with the addition of another vane. The vanes were closed in by circular endplates; when these were removed and the ends of the vanes left open, the power went down to 7 per cent. The corresponding power output with wheels having 4, 6, or more vanes was between 8 and 10 per cent with endplates, and 4 to 5 per cent without them.

The best of the rotor models gave 31 per cent, and the *u/v* maximum was 1.74. The best power output was given off at *u/v* = 0.85, but for *u/v* values between 0.65 and 1.1 the drop in power output was only 2 to 3 per cent. Fig. 3 gives the power diagrams for the S-rotor (1), the 12-vaned aeroturbine (2), and the La Cour wheel (3).

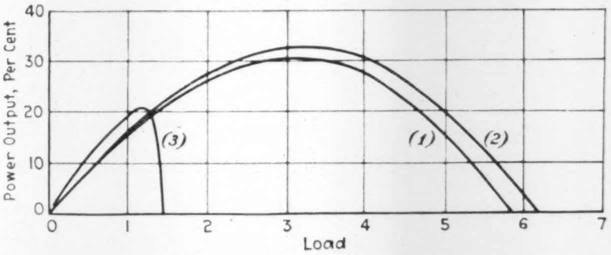

Fig. 3 Power Diagrams Taken in a Wind Tunnel and Showing Power Output in Per Cent of the Total Wind Power

[(1) power curve for S rotor; (2) power curve for 12-vaned steel windmill; (3) power curve for 4-vaned La Cour mill.]

The diagram shows that the power curve of the S-rotor is very similar to that of the 12-vaned wheel. Both have a "flat" top so that a comparatively great variation in load and speed makes little difference in the power output. The La Cour wheel is a typical high-speed wheel, with a very steep rise and a still steeper fall on the power curve, and if wheels of this type are even slightly overloaded they stop dead, and do not restart until practically all the load is removed.

During the time these wind-tunnel tests were in progress the author found that his results with the S-rotor were altogether in discord with the theories propounded in regard to vertical airwheels. The calculations of Professor Betz gave 20 per cent as the highest theoretical maximum for vertical airwheels, which under the best of circumstances could not produce more than 10 per cent in practical output. Against this the improved S-rotor gave over 30 per cent practical output. Either the author's tests and results were altogether at fault, or in making their theoretical calculations Professor Betz and the German school of aerodynamic experts had overlooked something of importance.

The tests undoubtedly showed that this was the case, and that this something which completely altered things was the asymmetric or Magnus streaming, which caused the whole effect of the rotary cylinder; but no one, even among the aerodynamic experts, seemed to have suspected that a rotor depending on wind power alone for its rotation could cause this asymmetry in the streaming.

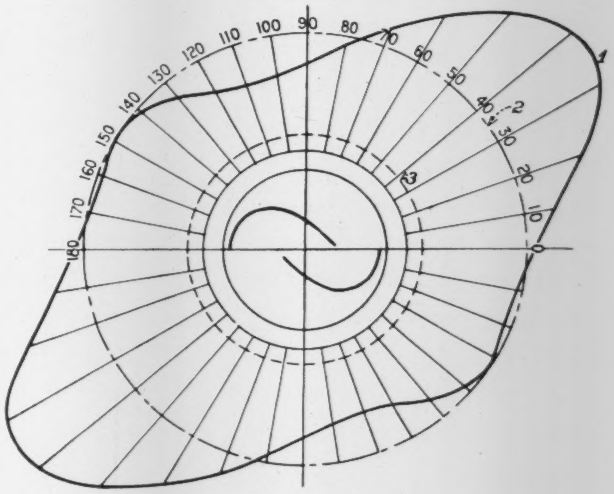

Fig. 4 Polar Torque Diagram

[(1) polar curve for S-rotor; (2) polar curve for 12-vaned steel windmill; (3) polar curve for 4-vaned La Cour mill. The latter two are circles.]

The Torque Problem

One more question remained to be settled. The S-rotor, having only two vanes, was not likely to have an unvarying torque through a whole revolution, and a lack of torque in some positions might make starting under load difficult. In Fig. 4 are shown polar diagrams for the S-rotor (1), the 12-vaned horizontal aeroturbine (2), and the La Cour mill (3). The latter two naturally are circles. The torque of the S-rotor at its minimum amounts to 61 per cent of the torque of the 12-vaned mill, and at its maximum is 100 per cent greater than the torque of this wheel. The 90-deg. position does not, as at first might be expected, give the greatest torque, the maximum occurring at an angle of 40 deg. Still more extraordinary, it seems that in the 150-deg. position, when the rotor presents its smallest area to the wind, there appears another maximum, equal to the torque of the 12-vaned mill, though in this position the wind is blowing over the back of the advancing vane. If area is taken into consideration the torque is at its maximum in this position. A study of the diagram, especially of the 150-deg. position, gives rise to some interesting speculations, as it offers a parallel to one detail of modern airplane design: the slotted wing of Handley Page. The relative sum total of torque for one complete revolution for the wheels considered is:

S-rotor, 100; 12-vaned wheel, 87; La Cour, 11

After the completion of the wind-tunnel tests the author continued his testing work in the natural wind. During these tests an earlier observation was confirmed, namely, that the S-rotor in the natural wind ran at a higher speed than in the wind tunnel and that the power output increased correspondingly, which was not the case with the horizontal aeromotors. The average power output as fixed by several tests rose to 37 per cent on the axis. Also the starting power under load was not inferior to that of the multi-vaned aeromotor of ordinary type. The windmill of ordinary type loses much power through changes in the direction of the wind, but with the S-rotor there are no losses on this account, as it is quite unaffected by such changes, no matter how large they are or how frequently they occur. The S-rotor can therefore instantly utilize any increase in the wind speed without having to lose time in getting into the right position. It is a well-known fact that a gust usually comes from a different direction from that in which the wind is blowing. The higher speed acquired stores energy in the revolving mass of the rotor, and when the wind speed again decreases this higher speed is maintained for a considerable time, which again causes a more pronounced asymmetry in the air flow, so that the rotor is able to utilize more than its strict share of the weaker wind following a gust. As compared to an optimum speed ratio of 0.85 in the wind tunnel, there is one of 0.92–1.0 in the natural wind.

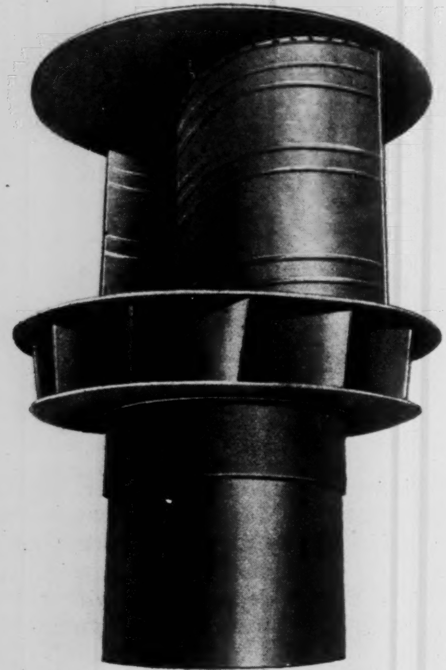

Fig. 5 Rotor Centrifugal Ventilator, Consisting of a Driving S-Rotor and a Driven Centrifugal Fan

Various Applications of the S-Rotor

It will not here be possible to describe the various applications which have been made of the S-rotors. However, they have been used in the form of an aeroturbine for pumping work and the generation of electricity; as pressure and exhaust fans; for moving advertising and outdoor signs; for an automobile mascot; for propelling toy rotorships; for stream recording in air and water; for airplane work in driving gyros, generators, and compressors; as water motors in river and tidal flow; as a wave motor; etc., etc. The principle has even been applied in a somewhat modified form to small steam turbines.

The S-rotor pumping plants were first tried in 1925 and are now in general use in the author's country, Finland. In these plants the S-rotor is fixed to a vertical shaft running on two self-oiling ball bearings situated in a central bearing tube rising half-way up the rotor (Fig. 1). The upper bearing is situated practically in the middle of the rotor, and the strains are thus taken up directly without any leverage. The bearing tube is fixed to the mast or tower raising the rotor to the necessary height over the ground. The power shaft is continued straight down to the ground level, or even deeper down, to the pump. There are no gears, levers, etc. as employed in ordinary wind-motor practice, only a straight rotary shaft, and therefore the friction and transmission losses as compared with those on ordinary mills are insignificant. The pumps employed are mostly of a special design, developed in connection with the rotor. The rotor is stopped and locked by a brake acting on a brake drum fixed to the rotor or to the power shaft. The smaller types work without speed regulation, the special ones allowing speeds up to 500 strokes a minute, there being no dipping rod to necessitate low working speeds. The larger types are regulated by means of air brakes consisting of small flaps which open out from the wing surface when a predetermined speed is exceeded. These flaps are actuated by centrifugal force and the regulation is not dependent on the wind speed, but only on the speed of rotation. In consequence they run very smoothly even in gusty winds. For different classes of work it is possible to choose the speed within wide limits. A rotor of large diameter and comparatively short in length runs at a slow speed and is suitable for heavy loads, while one of equal area but long and of small diameter can have a working speed several times higher, where such a higher speed is desirable, as, for instance, in running electric generators. The pumping plants are built in sizes from 1 sq. m. (about 11 sq. ft.) upward. A windmill of corresponding size would have a wheel 4 ft. across, but so far as the author is aware, no aeroturbines intended for practical work are built as small as this. Even the 1-sq. m. rotor, though diminutive in size, is capable of doing considerable useful work. Indeed under actual working conditions its output is only slightly less than for a 6-ft. wheel, the area of which is $2^{1}/_{2}$ times greater. The small friction and mechanical losses of the rotor give it a great advantage, especially when it is a question of comparatively small sizes.

In general, aeroturbines are limited to 8- to 10-ft. sizes, and in these sizes the S-rotor does not present any difficulties either in construction or in the matter of price. The S-rotor allows of unit construction, which is not possible with the ordinary windmill. This construction makes it possible to increase the power of an already existing plant by adding one or more units, all working on a common shaft. A plant of this description was some time ago supplied to the Indian Government, and is now in operation near Madras, supplying water for irrigation.

THE ROTOR VENTILATOR

Another application, a rotor ventilator, is of special interest from an aerodynamic point of view. In this a centrifugal fan is joined to the lower endplate of the rotor and the combination mounted on a central shaft on ball bearings over the suction pipe (Fig. 5). This arrangement was soon found to give an efficiency far better than that of any other cowl type which the author had tested before. Fig. 6, plotted from wind-tunnel tests, shows the great difference in performance between the ordinary types of cowls and the rotor ventilator. The uncommonly strong suction power it develops is of especial importance where air has to be drawn through ventilating ducts or pipes of considerable length, or where the air, due to lower temperature or other causes (mixtures of air and heavy gases, CO_2, gasoline fumes, exhaust gases) is heavier than normal. In many cases where ordinary cowls have failed to do the work, the rotor is doing it. The rotor ventilator is used for ventilating all kinds of buildings—factories, moving-picture theaters, schools, barracks, swimming baths, ice rinks, fortifications, ammunition stores, subterranean chambers, cable ducts, coupling boxes; and dynamite and gas works where electric fans are not allowed. For farm buildings such as stables, hen houses, dairies, storage cellars, pump rooms, granaries, etc., they are in great demand. Also on ships and motorboats of every type and size the rotor ventilator has found much use. The ordinary ship cowls are inefficient and often not watertight in heavy rain or spray, while the rotor lets in no water. For removing the gasoline fumes which are apt to collect in the bilge of a motorboat and which have caused so many explosions accompanied by loss of boat and life, it is excellent. It is always in action whether the boat is under way or at her moorings, and is simpler and safer than an electric ventilator. As a chimney cowl the rotor has no equal; being able to create a counter pressure exceeding the wind pressure, it will draw out smoke and stop backblow, even in difficult pressure positions. There are now in Europe ten concerns manufacturing these ventilators, one of the licensees being Anton Flettner, the well-known inventor of the rotor ship, who, the author is pleased to state, is recouping through this application of the S-rotor some of the economical loss he sustained in connection with the ship rotor.

THE S-ROTOR AS A CURRENT AND TIDAL MOTOR

And now a few words in regard to the latest, and in its way the most interesting, of the S-rotor developments. Early trials showed that the S-rotor worked in a water stream exactly in the same way, with the same u/v speed ratio and efficiency, as in an air stream. Water being about 800 times heavier than air, the power generated is greater in proportion. It is true that water movement is rarely as rapid as air movement (waterfalls excepted), but river flow and tidal streams with speeds of 2 to 3 meters per second are quite common, and even a speed of only 0.6 m. per sec. will give the same amount of power as an air speed of about $5^{1}/_{2}$ meters per second or around 12 miles per hour, which is a wind speed somewhat above the average. The formula for rotor power is hp. = $0.2Fv^3$. For a water speed of 2 meters per second, or about 4 knots, the power per square meter of rotor area would be 1.6 hp. Comparative tests made with underflow wheels gave only about one-quarter of this power with the same stream speed, the models being of equal size. The rotor works completely submerged, while the underflow wheel has only its lower quarter or the paddles submerged. The rotating speed of the rotor was about 6 times higher than for a paddle wheel with equal power, which is a decided advantage. Submerged under the surface, the wheel is well protected. It is not affected in its working by waves as is the case with the paddle wheel; it needs no elaborate dams, earthworks, channels, and chutes, but can be suspended from a simple and inexpensive frame or float. Another application occurring to the author, he moved the models from the

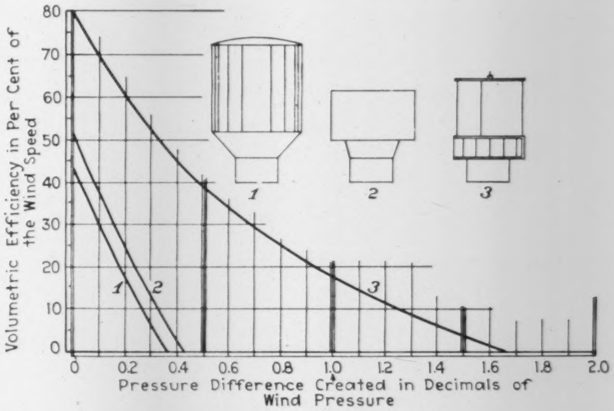

FIG. 6 DIAGRAM SHOWING AIR VOLUMES AND PRESSURE DIFFERENCES CREATED BY VARIOUS COWLS

[(1) Lloyd ship ventilator; (2) John HNA ventilator; (3) rotor ventilator. Note the great pressure difference created by the latter.]

stream where the testing was done to the seashore. There is no tide in the Baltic, but he had come to the conclusion that the rotor ought to be able to utilize the cycloidal movement of the waves as well as the current of a stream. The first test, in waves only a few inches high, confirmed this, and the bigger the waves, the more rapid was the rotation. In these trials the rotor was so completely submerged that it was covered in the trough of the wave. Even when it was sunk to a depth of four or five times the wave height it kept in motion. Due to the sheltered waters at the testing station, the wave action was not sufficient to admit of any trials on a greater scale, but the idea was taken up by the director of the Institut Océanographique at Monaco, Mr. Richards, who had a small double rotor of 0.4 sq. m. area made for testing work. This was coupled to a pump, with a stroke volume of about 0.5 liter, and with this small plant he was able to raise water solely by wave action 6, 8, 10, 20 meters, and finally to a height of 34 meters. The power obtained was at times 1.6 hp. per square meter. This small plant having worked so well, it was decided to build a new one, consisting of three rotors mounted on the same shaft with a total area of 3 sq. m., for the purpose of raising water to the aquariums of the Musée Océanographique. This plant has now been in operation for some time at Monaco. The rotor is fixed in a sort of cavity worn out of the rocks at the water line by the waves (Fig. 7). This cavity is so shallow that a third of the rotors are out of the water, and in the wave trough or when the waves recede they are entirely so. Because of the proximity of the rocks the greater part of the power of the waves is spent in impact and friction, and the interference in the wave action is considerable. In spite of this the rotor is driving two double-acting pumps, lifting the water to a height of 200 ft. A power output of from 1.8 to 2.7 hp. per sq. m. is attainable with a wave speed of about 3 m. per sec.

As far as the author is aware, the S-rotor is the first machine which has been able to turn wave action into a unidirectional rotary movement for power purposes. As to whether it will be better to pump the water to elevated reservoirs and obtain power therefrom by turbines, or to drive machinery (generators) directly, it seems that under favorable conditions, where regular seas can be harnessed, a direct drive through a suitable speed-compensating device is by no means out of the question. The form of the rotor is such that it has a great inherent strength, so it will not be more than a matter of proper dimensioning to make such a plant able to withstand even the heaviest seas, inasmuch as the rotor is not absolutely unyielding to the water movement as are rocks, a solid pier, or the side of a ship.

It is not intended here to convey the impression that the water and wave rotor would be suitable for power plants of such magnitude as those contemplated by M. Georges Claude, utilizing the temperature difference of different levels of the tropical seas, but only in a more limited way and for comparatively modest power amounts. A small and inexpensive rotor plant working in a river or in a tidal creek, and requiring no expensive earthwork construction or ducts, could extract quite a considerable amount of power for use in irrigation and for supplying light and power to farms, villages, and habitations along the banks. The use of such rotors in suitable locations is just as simple a matter as that of windmills for pumping and electric work, and the cost of the plant about the same.

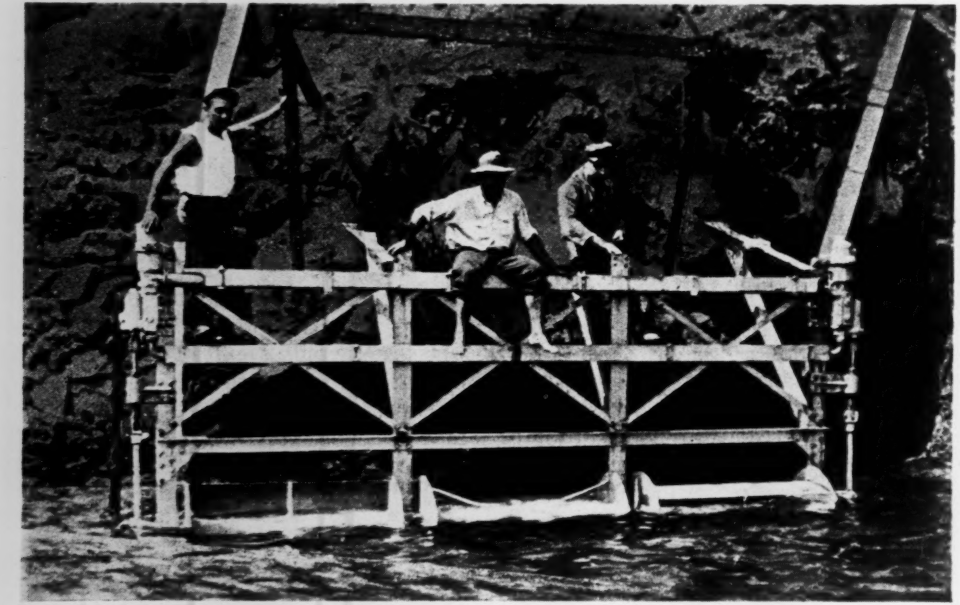

FIG. 7 THE WAVE ROTOR AT MONACO
(The triple rotor situated in a shallow cavity in the shore rocks, works two double-acting pumps which elevate the water to a height of over 200 ft. The power is supplied solely by the wave action, the rotors converting the oscillatory wave movement into unidirectional rotary power.)

A Modern Mill Village With Paved Streets, Concrete Sidewalks, and Concrete Walkways to Front Porches of Cottages

Trends in the Cotton Textile Industry

A Review of Past Progress and Future Possibilities, Dealing More Particularly With the Housing of Employees, Building Design, Humidity and Heat Control, Illumination, Machinery Speed Control, the Labor Problem, and Research

By C. L. Emerson,[1] Atlanta, Ga.

THE textile industry was the first to emerge from the handicraft era into the machine age. The first factory to be driven by Watt's steam engine was a cotton mill. The form of process and design of textile machinery were accordingly crystallized very early, compared with those of other industries. After the first development there followed a period characterized by almost complete stagnation, except for detail improvements. Some ten years ago business became very difficult for the manufacturers of textile machinery, and with some minor exceptions has so continued up to the present writing. These very difficulties have produced many improvements in design and construction of such machinery.

The initial process in the cotton mill, that is, the opening up of the bales, felt the first impetus of development. The entire mill operation was bettered by a more thorough cleaning of the fiber before it reached the picker room. Among the machines introduced were vertical openers, beaters, and air cleaners. In the study of cotton preparation, it developed that there were advantages in providing a rest period in bins for loose cotton. This permitted the fibers to uncurl and aerate, and made the succeeding operations easier.

Most mills formerly used three lines of picking machines in series. This practice is being superseded by the one-process machine which during the last year or so has found universal acceptance. This picker not only materially reduces the labor required, but also produces a cleaner and more uniform lap for the card room.

In spinning, long-draft equipment has made a definite place for itself. This device has roughly doubled the amount of drawing out done on the spinning frame, and thereby reduced the amount of preparatory equipment needed between cards and spinning frames. Old mills installing long draft need to make a complete restudy of these preliminary operations. Long draft has resulted in the production of a more uniform yarn and reduced the requirement for operatives in the preliminary processes.

The system of warping and spooling which was in general use ten years or more ago is now entirely obsolete. High-speed spoolers making disk-shaped packages for use in specially designed high-speed warpers, or else special winders with warpers of the usual type but redesigned for high speed, have replaced them. On account of the large hourly production the number of machines required has been reduced, with a corre-

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sponding reduction in operatives and required floor space.

Past experimental work is bringing us today for acceptance a new type of carding machine with less than half as many flats as the present design, and also a clothing of straight wire which may not require as much cleaning. A subsidiary device is offered which strips continuously with the card in operation.

A new type of automatic loom is about ready for the market which, among other advantages, permits higher picking speed on account of its heavier design, and which has a device to divide the warp as an indicator at the broken thread.

Thanks to redesigns over the last ten years, machines are now available which in general have heavier construction, more accurate fits, more precision in operation, and other features that permit higher operating speeds. A feature of many redesigns has been the incorporation of anti-friction bearings.

Development goes on, and we look to the future for still better equipment. Experiments are being made to apply longer drafts to drawing frames. There are interesting possibilities in the use of materially larger packages in spinning, although any great advantage here may necessitate new materials for rings and travelers, or else some new device to replace the traveler.

A still more remote possibility is the combination of two or more operations into one by the production of a new machine. Slubbers, intermediates, and roving frames might be thus combined, or the spinning frame and spooler be put together to produce a package going direct to the warper creel. Nothing practical, however, is yet in sight along these lines.

To generalize concerning these trends in machinery, it may be said that speeds have increased, and, in consequence, production per machine. The number of operatives per pound of product is materially reduced. These effect a reduction in floor space and village housing, and ultimately in the cost of machinery to furnish a given output. A better and more uniform product is made. The future seems to hint a continuation of these improvements, but at a less rapid rate.

Village Housing

In recent years most of the new plants have been located in the South, and in the smaller communities. In such places only a few vacant houses are ordinarily available, so unless the owner was willing to wait until some real-estate operator would build cottages, he had to do this himself. Further, had the matter of housing been left to outsiders, the employees would have been subjected to high rents and lack of desirable utilities, while the owner would have had no semblance of control over the situation.

The village is not a profitable renting venture. As a rule, the rental is about fifty cents per room per week, or about $9 per month for a four-room cottage. With the house is given free and unlimited use of water and electricity. On such a basis, one particular village known to the author returned 3 per cent on the investment after deducting maintenance and the cost of water and light. This was without depreciation, which, at 4 per cent, converted this construction into a losing investment. The excellent housing obtained by the workers at less than the cost of providing it is to be regarded as extra compensation beyond the cash wages they receive.

The improvement made in the living conditions in these mill communities is perhaps the most striking change in the industry during the last few years. The village in early days consisted of rows of houses built as cheaply as possible, all exactly alike, and all painted the same color, if painted at all. There were no conveniences of any kind. Modern conditions contrast very strongly with this. Not only are the cottages well built and comfortable, but the variety of appearance and the curving of streets give the impression of a moderate-priced city suburb.

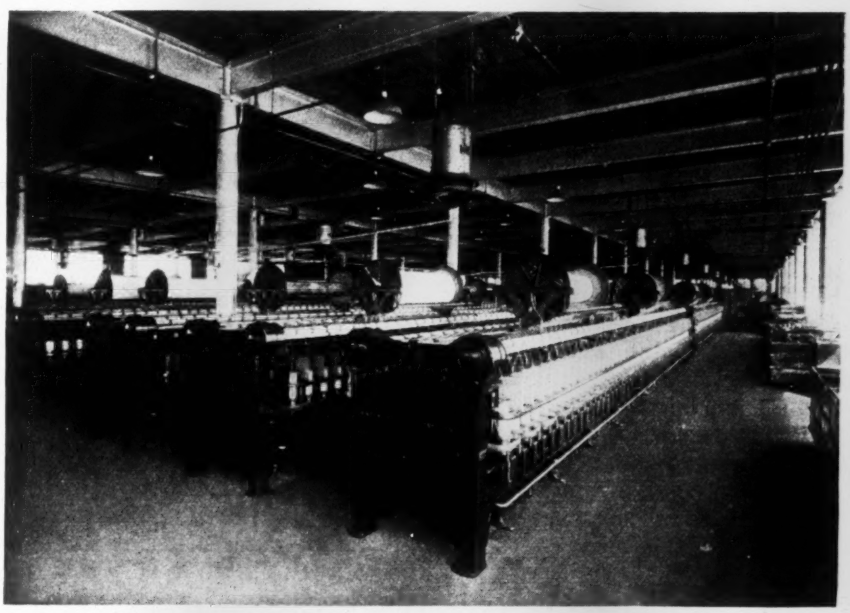
Most of the recent villages supply every house with water, electricity, sewerage, and plumbing. There must also be garages for the cars of the operatives. Some or many of the following features are always included: churches, stores, motion-picture theaters, schools, auditoriums, natatoriums, lodge rooms, gymnasiums, and community houses. Street improvements, including "White Way" systems, paving, and landscaping, are not uncommon. The miniature city is becoming quite up to date.

Cottages have usually been of frame construction, although recently quite a few have been of brick veneer or stucco on hollow tile; but the saving in maintenance, depreciation, and fire risk of the latter types does not compensate in dollars and cents for the greater first cost. The housing development has become so expensive that any extra cost per room must be avoided. In the effort to obtain the advantages of brick construction at a cost comparable with frame, many experiments have been made. That offering the greatest possibilities for the future seems to be the use of a loose wall construction of hollow cinder-concrete blocks covered and cemented together with gunite. This spraying of concrete through a hose with compressed air increases the rapidity of construction and reduces the requirement for skilled construction labor.

The importance of the great improvements made in the living conditions of the textile operatives can be fully appreciated by observing the corresponding improvements in the operatives themselves. The level of intelligence, loyalty, self-respect, and physical well-being has been appreciably raised. This can be observed even by a casual comparison of the employees of modern mills such as are described above with those of others which have been backward in improving their villages.

Buildings

The fire hazard in processing cotton is ever present, as the blanket of fine filaments is highly inflammable.



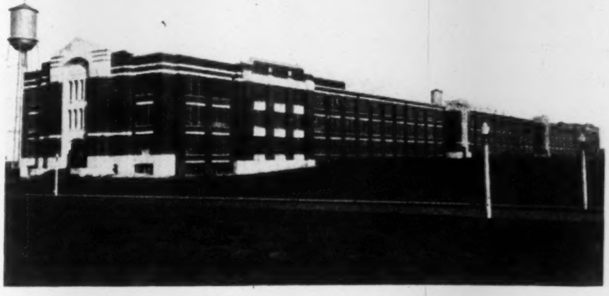
Interior of a Modern Twister Room. The Light Is Very Good, Although the Ceiling Has Not Yet Been Painted

The mill is required not only to provide automatic sprinklers throughout, but also to use slow-burning, or fire-resistive, construction. The latter requirement for many years was successfully met by the so-called "standard mill construction" using heavy wooden columns and beams.

Beginning some fifteen years ago, two trends came into play affecting building construction. One had to do with the substitution of more imperishable materials for wood; the other with providing better working conditions for the employees.

It is unnecessary to catalog the various steps in this progression, but considering present practice we find cast-iron pipe or structural-steel columns in place of wood. The difficulty in obtaining large timbers of long-leaf pine has led to the substitution of steel-beam or beam-and-girder construction. Steel sash is now almost universally used. Concrete has also had a share in replacing wood and, to some extent, brick in foundations, column footings, window sills and lintels, stairways, platforms, floors in exterior towers, etc. Wood is retained only for main floors and roof plank. Its resilience and economy as compared to concrete keep it in favor here. Even for this planking, however, the quality is slowly deteriorating, and various forms of treatment are being used, such as zinc chloride impregnation.

Great improvements, particularly in the last few years, have been made in the conditions under which labor performs its tasks. Column spacings have been extended from eight feet to twenty feet, and ceiling heights from ten feet to seventeen feet. This gives an opportunity for large windows, and in certain modern mills 58 per cent of the side-wall area is glass. The natural lighting is most excellent, and ventilation has been improved. On upper floors it is customary to provide large monitors which still further help the circulation of air. In one-story weave sheds and in finishing plants, sawtooth construction is frequently used which, while somewhat costly, is particularly advantageous for both light and ventilation.



Showing the Improved Architectural Treatment of a Modern Mill Building

The sanitary conditions have undergone a change for the better. All toilets are now housed in outside towers which also contain washrooms and, in some instances, locker and rest rooms. These towers contain no wood. Their concrete floors, tile walls, and steel partitions permit the entire area to be washed down with a hose. One of the greatest contrasts between the old-time mill and the new is the cleanliness of the latter. The interior is painted white and usually kept so. Lint and other waste are kept off the floor. Particularly dusty areas such as card rooms are cleared by vacuum devices.

Certain minor improvements are being made. A group of these concern the elimination of difficulties of condensation. High humidities must be carried in certain departments, and during cold weather the condensation on the roof and the large glass areas of side wall cause water drip. Roof insulation is being more frequently used, although no entirely satisfactory material is yet available for this purpose. A subsidiary advantage of insulation is the protection it affords from the hot summer sun.

Another difficulty introduced in some mills by large glass area is that of glare. Here actinic glass has had a useful field, as it materially reduces the heat as well as the glare transmitted, while reducing only slightly the admission of light. Another new form of glass is now on the market which admits a considerable proportion of the ultra-violet rays excluded by ordinary glass.

The most recent development has to do with an increased demand on the part of many owners for architectural excellence as well as engineering correctness in their structures. There is little return on money spent for extravagant exterior decoration, but pleasing results can be obtained by proper handling of proportion and fenestration, and at low cost.

The trend toward the use of structural steel may result in the future in its substitution for the present brick bearing walls. The curtain walls surrounding the sash may still be of brick, or if the cost of labor or material for brickwork advances, a substitute may be found in hollow wall faced on the inside and outside with cement blown in place from a cement gun. The rapid advance in the welding art may result in this form of connection, particularly if some satisfactory method is found for investigating the strength of the weld after completion. This hypothetical development will require from the engineers a complete redesign of the details at connecting members to take best advantage of welding.

Auxiliary Services

Appreciation of the importance of various auxiliary services in obtaining better, larger, and more uniform production has grown remarkably in the last decade. The setting of proper humidity, the control of heat, the supplying of ample artificial illumination, the precise control of speed, the reduction of many forms of waste, have won their way by the most practical and decisive demonstrations. The net result has been that the conditions under which work is done have been placed definitely under the control of the manager, instead of being left to chance. By and large, he can set these conditions where his best judgment indicates, and then maintain them there and have records to tell him that they have been maintained. This group probably shows most clearly the handwriting of engineers in the industry.

To particularize, the temperature of mill space in winter had formerly been left to the judgment of various foremen, who regulated it by means of a hand valve. Busy with other duties, these men would disregard the heating system until uncomfortably hot; then would cut off steam entirely and leave it off until the room became too cold. These temperature fluctuations had a twofold disadvantage. First, the operatives suffered in efficiency, particularly from overheating; second, processes were interfered with. Machine settings and oiling conditions were disarranged, but humidity conditions in particular were immediately upset. This can be readily appreciated on considering that with a temperature of 75 deg. fahr. and a relative humidity of 69 per cent, the air would contain 0.929 lb. of moisture per 1000 cu. ft. When the temperature dropped to 65 deg. fahr., substantially the same amount of moisture would be present, but the relative humidity would be 95 per cent. The humidifier controls would operate, but it would take some time for proper conditions to be reestablished. Cotton processing is sensitive to humidity conditions, and these fluctuations would affect the operations adversely.

Automatic heat control has taken over this situation. The steam is turned off and on by a diaphragm valve operated by compressed air. This in turn is controlled by a pilot valve operated by a thermostat. Temperature is maintained within one degree, and may be set at any desired point. The system pays its way in the savings at the coal pile of the heating plant, so the attendant advantages are obtained without appreciable cost.

Unit heaters should be mentioned as one of the newer developments in the heating system. These are replacing pipe-coil radiation to some extent, particularly in those departments where there is little lint or fly. Their fans create an air circulation which is particularly valuable where fan-type humidifier heads are not installed.

Trade practice in textiles is to allow $8^1/_2$ per cent by weight of water in goods purchased. As the output of weave mills is usually sold to some one else for further processing, any less water in the stock means a direct loss to the mill. This water cannot be suddenly injected in the cloth room, but has to find its way into the cotton even before it reaches the loom. Moreover the work in all processes needs just the right amount of humidity to make it run best. The importance of humidity is readily recognized. In this climate it is necessary to supply moisture at practically all times, and mechanical systems have been in use for many years.

The atomizer system has been practically superseded by other types, and at this time most of the installations use heads with motor-operated fans, or the so-called "high-duty-head" systems. In certain mills, particularly in the weave sheds, central-station systems have been installed where the air is collected at one point, heated, humidified, and piped in ducts to numerous outlets.

Humidifier controls have been refined and improved to a point where their operation is quite satisfactory. In addition to the beneficial effects on mill operation, present-day humidifiers do considerable cooling in summer. It is not uncommon to have the mill interior 7 deg. cooler than the outside atmosphere. With the central-station system, an even greater cooling effect can be obtained. The efficiency of workers, particularly in Southern cotton mills, where the summers are long and hot, is enhanced by the circulation of cooled air.

The most recent improvement made is the application of humidification to picker rooms. This department has long defied the engineers because of the great volume of air circulated by the pickers themselves. It is particularly interesting that the solution of this problem came from a mill manager, and not from a humidification engineer.

The problem of heating and humidification has by no means been completely solved. Experimental work is now under way on small units which will both heat (or cool) and humidify. In fact, such units are on the market, but on account of excessive cost and other disadvantages from a cotton-mill standpoint, are not yet acceptable. This field appears to offer great possibilities for the future. Another effort which will offer remuneration is a study by the mills themselves of the precise degree of humidity which will give best results for a certain product and a certain grade and staple of cotton. Adjustments are at present made principally by rule of thumb.

The improvement in the control of the operating speed of the textile machinery is to be attributed largely to the work of the manufacturers of motor equipment. In the old days of mechanical transmission there was a rope race, a head shaft, and then a maze of countershafts, counterbelts, and machine belts. This has all been swept away. As far back as ten years ago individual motors had been applied to every textile machine. One of the last of these was the card, and the card room is still the one department in which shafting is commonly used.

There is an interesting history as to the application of individual motor drive to each of the textile machines, but it is sufficient to say that the difficulties have been surmounted and a satisfactory drive is now available for each.

Motor drive has resulted in the elimination of belt slip, and of torsional whip in long shafts. This translates itself into a more even speed at the machine. The regularity of all machines permits an increased average speed throughout, resulting in an increased production. In changing over old mills from mechanical to electrical drive, increases have ranged from 2 to 12 per cent, depending on the inefficiency previously existing.

There is at present a strong tendency to build the motor into the machine as an integral part of it. This is entirely logical and may eventually result in all machinery's being individually driven and in the motors' being sold with the textile machinery. The problem of adjustable speed for spinning frames still waits for a solution after twenty years of effort. The frame speed should be increased as the bobbin fills up. At first thought it would seem simple to accomplish this, but it has not been done successfully. Experiments are being carried on with a mechanical device which shows some possibilities, and tests have shown a sufficient increase of production to make it commercially attractive if the device can be perfected.

Artificial lighting has been increased greatly in intensity. It has been found that enhanced efficiency of operatives under better illumination makes it a good investment. Foot-candle illumination has increased from an average of three to an average of five. In some departments, particularly weaving and cloth room, 7 foot-candles are frequently used.

The ordinary system of lighting has been standardized for several years on the use of 150- or 200-watt incandescent lamps on drop cords, with steel reflectors having the underside enameled.

Certain new-type units are being put on the market using the mercury-vapor light in combination with an incandescent filament and with a globe to permit the passage of ultra-violet rays. There is also the possibility of introducing some inert gas into the mercury-vapor tube to supply red rays so that colors under the light will be normal.

LABOR

Scientific method and technical study have now provided the industry with excellent machinery, and with buildings and auxiliary services which afford satisfactory conditions for its efficient operation. It is only within the last few years that the same methods have been directed toward improvements in the human element in mill operation.

Other industries have pointed the way, but the textile has lagged behind on the plea that scientific management could not produce for it the results obtained elsewhere. Some mills, however, have had the energy and courage to pioneer in this field, and the results have been most encouraging. One plant, after instituting a thorough study and reallocation of the tasks of its operatives, was able to reduce the number on the payroll by 35 per cent, while those remaining increased their earnings by 25 per cent. In one department, the average hourly earnings increased from 26 cents to 34 cents.

Textile has been known as a low-wage industry. It has also suffered, particularly in the South, from a high labor turnover and from a considerable amount of voluntary absenteeism. The latter condition has necessitated a large force of spare hands, whose presence has increased the overhead cost of village operation.

The labor problem is being studied from two angles. One group approaches the problem primarily by way of the machine, and the other purely by way of the human element. The first group makes a comprehensive study of machine settings, including twists and drafts, and compares these with data carefully accumulated at other successful plants. Corrections are then made where necessary. All subsidiary services are studied so that production may take full advantage of the best conditions of speeds, humidity, light, and so on. Beginning with the opener room, all processes are restudied and set so that the final process, say, weaving, may have the benefit of the best possible yarn. There is also set up a schedule of machine inspections which is designed to locate and eliminate sources of breakdown before the stoppage occurs.

Having effected these various improvements the tasks of the operatives are extended. A man who has been operating forty machines may be given sixty. The improvements are explained to the employees, and they are supposed to receive an equivalent increase in pay for extra work done. These matters are most important in securing their willing cooperation on the basis of a square deal for both men and management. Incidental to this is the use of the multiple system, which merely delegates easy tasks requiring no great skill or intelligence to low-paid helpers, thus relieving the skilled workers and permitting them to tend more machines.

The second group leaves the matters of machinery and its settings to the management and focuses its attention on labor alone. An exhaustive time study is made of the operations involved in each process, and a standard of performance is set up as a yardstick to measure acceptable or average work. With these standards as a basis, rates are set up and bonuses are provided for those who exceed them. Inherent in this plan is the minimum wage at the standard rate for those who cannot even reach the easy requirements. It devolves on the management to replace those who cannot in time attain the standard. Most bonuses are based on production, so that pick counters, hank clocks, and other measuring devices are required. The supervising forces are drawn into the plan by bonuses based on the combined production of the direct labor under their supervision.

This wage-incentive plan has had a marked effect in increasing the interest of the operatives in keeping their machines tuned up and in production as constantly as possible. Even card rooms have shown a large increase in output after the installation of a bonus system. The superintendent and the foremen are prompted to become teachers of the help, interested to improve their efficiency.

The next great change in the industry will probably have to do with this human element rather than with equipment or buildings. We have noted many factors which are reducing the number of operatives required in a plant of given size. This reduction permits more study and effort to be expended on those remaining. The better living and working conditions afforded by progressive mills cannot but eventually have an effect in reducing labor turnover. It becomes profitable to train workers if their services can be retained.

These studies in "humanics" will undoubtedly include a more scientific and careful selection of those employed, a systematic program of training them not only for their particular tasks but for advancement, and also various forms of incentives—particularly wage incentives, of course—to increase their interest and effort.

A factor which may accelerate this trend is the gradually increasing number of men in executive and managerial positions who have had engineering training and who are basically in sympathy with the scientific method. Such management will appreciate the advantage not only of great, but also small, matters such as the use of a few young technical men to continually check speeds, humidities, light intensities, and machine settings.

RESEARCH

The textile industry has not utilized research to the same degree as have, for instance, the electrical or chemical industries. While some of the larger units in the textile field have well-equipped testing laboratories, where some practical research is done, there has been no organized cooperative research by the industry. It may be that any extensive research effort will have to wait for years, but interest is being awakened and opinion directed toward such a program. It is to be hoped that some practical plan can be found to utilize the facilities of those of our technical colleges which have courses in textile engineering. They have libraries, laboratories, mills, and shops valued at many million dollars, and it is only from them that a future supply of trained research workers may be obtained. The industry could contribute much to the colleges, but under proper auspices the colleges could make equal contributions to industry.

SUMMARY

Consolidating our trend curves and studying them, we find an industry rapidly becoming more technical and scientific, but with plenty of room left for improvement. We find living and working conditions of operatives revolutionized in the last ten years. With these improvements we are gradually getting a better class of people in the industry. Their wants are increasing, and therefore they need and will receive more compensation. On the other hand, the industry is beginning to demand that they remain in one place, learn to do their work properly, and work regularly and with reasonable efficiency. This represents the next great field for improvement in the industry.

One of the economic trends of the cotton textile industry has been its rapid centralization in the South. This general fact is very well known, but it is rather surprising to note that of the active spindle-hours worked for October, 1930, almost 75 per cent were in the cotton-growing states. Unquestionably the plants finishing cloth, whether they be dye plants, bleacheries, or printing establishments, will eventually follow this geographical movement.

The industry is a disjointed one. One organization produces cloth from cotton, another processes it, another sells it, and there may be one or two other middlemen between the sales organization and the ultimate consumer. There must be a process of integration or else the bitter conflicts between buyer and seller within the industry will limit its economic success.

Even more difficult to cure are the wild fluctuations in the price of the raw material, cotton, which has run from ten cents a pound to forty cents and back again in a few years, with further erratic ups and downs during each year. The disjointed and highly laminated structure of the industry intensifies these price vibrations and results in a chaotic condition in the New York goods market.

Perhaps men have not sufficiently advanced to take such an economic condition and, by cooperative effort, solve it, but at least it stands—along with the other problems—as a challenge to industrial leaders with scientific minds.

SOME OF THE KNOWN HYBRID POPLARS
(Left, *P. regenerata;* center, Lombardy and *P. robusta;* right, *P. generosa.*)

New Hybrid Poplars for Pulpwood

Impending Shortage of Pulpwood for Paper Making—Developments of New Hybrids That Grow Over Ten Times as Fast as the Trees Now Used for Pulpwood, and That Promise Farmers an Added and Highly Profitable Crop

BY RALPH H. McKEE,[1] NEW YORK, N. Y.

MOST of us take the enormous quantities of books, magazines, and newspapers for granted. It has been said that:

> There never was paper enough in the world until it was made of wood. But little more than 30 years ago an English authority hailed the development of the use of wood as supplying an "inexhaustible source" of useful fiber for paper making. Today we know that our resources are being drawn upon too heavily, and that without better forest protection and more care for reproduction the pinch of scarcity of paper-making materials will again be felt.[2]

White paper used for printing purposes consists normally of 75 per cent wood pulp, 15 per cent clay or other filler, 7 per cent moisture, and 3 per cent of alum and rosin sizing. The foregoing may be taken as typical of most papers used for printing, excepting for newspaper, which contains less sizing and clay and more, but lower-grade, wood pulp. For printing papers we use primarily ground-wood pulp and soda pulp, and in addition, in order to increase the strength of the paper, some sulphite pulp. For example, in newspaper the fiber is generally about 80 per cent of ground-wood pulp and 20 per cent of sulphite pulp. In a book paper such as is used in magazines the fiber consists generally of about 70 per cent of soda pulp and 30 per cent of sulphite pulp.

Ground-wood pulp is made by taking a short log, say, 2 feet in length, of a wood with but little color, say, spruce or poplar, and pressing it against a wet, rapidly revolving grindstone. The log is pressed side on against this grindstone so that the fibers are broken as little as possible in the disintegrating process. For sulphite pulp similar wood is cut into chips and the chips cooked with an acid solution consisting of a solution of lime in sulphurous acid. The chemicals dissolve the non-fibrous portion of the wood, leaving the cellulose fibers to be screened out, washed, and bleached before they are ready to use. In soda pulp, poplar or similar wood is cooked in an alkaline solution, such as a 10 per cent solution of caustic soda, with the result that the alkali dissolves out the non-fibrous material, leaving a pulp which after bleaching gives a product fit for the making of paper.

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[1] Professor of Chemical Engineering, Columbia University.

[2] Kellogg, R. S., "Pulpwood and Wood Pulp in North America," McGraw-Hill, 1923, p. 15.

Abridgment of paper presented at the Second Conference of the Technical Experts in the Printing Industry, Washington, D. C., March 16 and 17, 1931, under the auspices of the Printing Industries Division of the A.S.M.E., the Government Printing Office, and the United Typothetae of America.

That this type may give the clearest impression the printer needs to use a soft-surfaced, opaque paper, and for the better grade of publication, permanence and strength are also desired. Accordingly the best printing papers are made largely from soda pulp with just sufficient sulphite pulp added to give the needed strength. Translucence can be overcome by the addition of a filler such as clay, but this helps little in giving clearness to the typed impression.

Present Pulpwood Requirements

It is not commonly appreciated how rapidly the supply of pulpwood is decreasing. There are 16 daily newspapers in New York City which, on an average, use the wood from 75 acres of forest land each day. This means that for pulp purposes more than 7000 acres of forest land will be cleared for each week's publication exclusive of Sunday. A single issue of the Sunday New York *Times* or the Sunday New York *American* clears 400 acres of forest land. Accordingly, if to these daily papers there be added that required for the Sunday papers, we shall closely approach a figure of 10,000 acres of pulpwood land cleared of timber for each week's newspaper printing in New York City alone. It will be 60 years before this land is again ready to be cut for pulpwood.

Some of the Best of the Hybrid Poplar Seedlings
(In 3-in. pots and about three months old. When sixteen months old they reached heights of 5 to 7 ft.)

In this country in the several paper-making sections we are cutting pulpwood from four to six times as fast as we are growing it. Indeed the supply is already so short that more than 50 per cent of the paper used in the United States is made from foreign-grown pulpwood. Most of this imported paper, pulp, or pulpwood comes from Canada; but in addition we do get very considerable amounts from Sweden, Norway, Russia, Finland, and other European countries.

Substitutes for Wood Pulp

This situation is naturally reflected in the price of paper and of pulpwood. Manufacturing costs for paper have been considerably reduced in the last two decades; but the price of the raw material, that is, pulpwood, has, on the other hand, continually risen. Pulpwood which in 1903 was worth $5 a cord, delivered to the American paper mill, in 1916 cost between $10 and $11 a cord, and today averages approximately $25 a cord when all costs to the mill are included. It may be expected to rise about $1 per cord per year until it reaches a price at which it will become possible to use agricultural-crop by-products such as cornstalks, wheat straw, flax straw, cotton stalks, and the like. I have attempted to make some calculations to see when it will become profitable to use these materials in the present known methods of making paper pulp. In my judgment it will not be profitable to use such natural by-product farm crops as cornstalks, etc., until pulpwood is approximately $40 a cord delivered at the pulp mill. With this rise in price of pulpwood will, of course, come a corresponding rise in the price of paper. An increase from $25 to $40 a cord in the price of pulpwood will raise the price of paper more than twice this differential. In other words, when pulpwood is $40 a cord we may expect paper to cost between $30 and $45 a ton more than it does at present.

Today I want to discuss with you one attempt which gives perhaps the most promise of meeting this shortage of paper, and, moreover, it is important in that it meets a need of the farmers of our country for another kind of agricultural crop which will not compete with the food crops they are now, unfortunately, overproducing.

Forestry Research

Among the wood-using industries the paper-pulp industry has made by far the most progress in industrial research—more in fact than all the other wood-using and lumber industries combined.

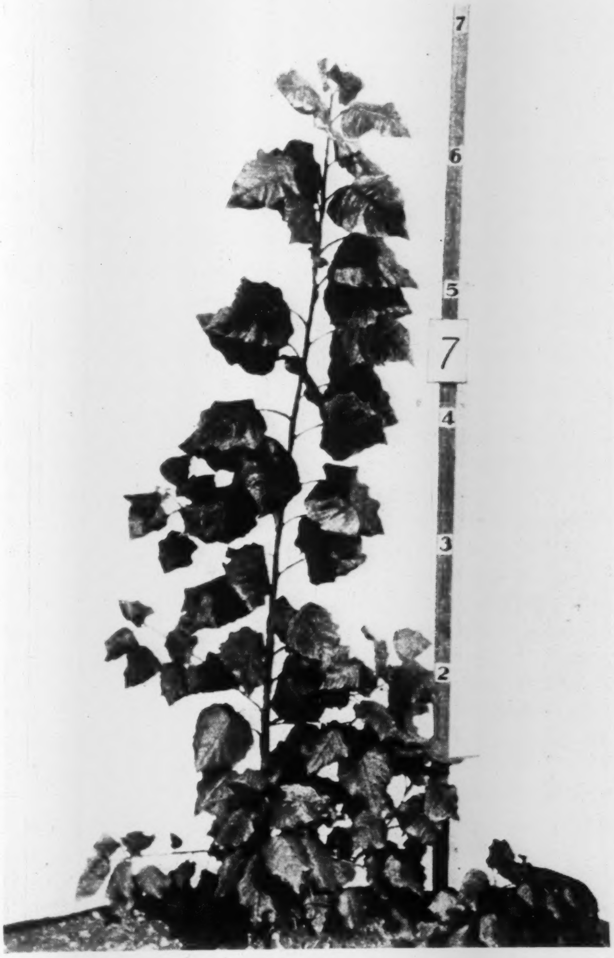
The expenditures made on forest research do not exceed $3,000,000 a year. Of this over $1,500,000 is spent by the United States Government, perhaps $250,000 by the several states, about $100,000 in endowed institutions, and perhaps $1,000,000 by the wood-using industries. Of this $1,000,000 about half is spent by the paper industry. On the other hand, there is more than $25,000,000 annually paid for the protection and administration of forest lands and in reforestation, most of it by public agencies such as the United States Government.

Two-thirds of the States are using more wood than they grow and are on the road to forest bankruptcy. The idea of trees as a crop must be adopted and extended if wood starvation is to be kept at bay. The

United States, China, Australia, and the southern part of Africa are already importers of wood. Each of these countries is producing a part—but only a part—of the wood it needs. Since most trees must grow for 40 to 60 years before they are of much use, a very bad time is ahead, beginning about 1940 or 1945, unless something is done to change the situation.

It is common knowledge that agricultural crops, such as wheat, oats, rice, corn, etc., have been improved by hybridization and selective breeding. Among tree crops hybridization has yielded conspicuous results in certain fruit and nut trees and in a few ornamental varieties. It is but logical to expect similar improvement in forest trees suitable for pulpwood and lumber if we apply the methods of hybridization.

Hybrids grow faster and are freer from disease than their parents. Perhaps I should indicate the rate of growth of the woods at present used for the manufacture of pulp. Trees are ordinarily measured at breast height. A spruce which has an 8-in. diameter at this height is approximately 90 years old. A white pine of this size is approximately 70 years old, and the ordinary aspen or poplar, such as is used for paper making, is 45 to 55 years old. Other trees used for pulp have approximately this same rate of growth.



One of the Best of the New Hybrids. Good Growth; Propagates Easily by Cuttings

On studying the question of obtaining faster-growing pulpwood trees by hybridization it appeared that poplars gave the greatest promise. Moreover, there were five hybrid poplars in existence, so that we knew that crosses could be made.

These five known hybrid poplars are the Lombardy, *P.* (*populus*) *regenerata*, *P. Eugenei*, *P. robusta*, and *P. generosa*. You are most familiar with the Lombardy poplar, which was an accidental hybrid about 400 years ago in the north of Italy. It does not in this climate grow to be of any considerable size. It is particularly subject to a wood-rotting disease which brings about its death ordinarily at an age of around 20 years. It is a fast-growing tree and is particularly desirable for ornamental purposes because of its upright manner of growing. The *P. robusta* is an erect type of tree with most of the wood in the trunk, and if it grew fast enough would be a good pulpwood type of tree. In this country we also have considerable numbers of the Carolina poplar (*P. Eugenei*). It is a handsome, rather fast-growing tree with small branches and grows tall. *P. regenerata* is a much more branched tree and not so erect as *P. robusta*. When grown to a large tree the *P. generosa* is a much-branched and undesirable type of poplar so far as commercial use is concerned. Branches are useless when it comes to the manufacture of pulpwood. In general, other pure species of poplars do not meet the ideal form, that is, a tree with a large, tall, straight bole and few branches.

We wanted trees which would grow rapidly, be free from diseases, have a large, tall, straight bole with few branches, and which could readily be propagated by cuttings. We desired, if possible, a tree having a fiber length increased over that of the ordinary poplar. I am glad to say that we have succeeded in getting a number of hybrids which meet all these requirements.

PRODUCTION OF HYBRID POPLARS

Our first problem was to locate the different varieties of poplars in this country. The largest collection was found at Highland Park in Rochester, the second largest at New York Botanical Garden. Other locations which furnished particular trees were the Arnold Arboretum in Boston and certain Long Island nurseries.

Before the flowers on the female trees opened, paper sacks were tied over the clusters to prevent normal pollination. Later, when they opened, pollen was obtained from the flowers of the selected male tree and dusted over them, after which they were immediately recovered with the sacks.

Six weeks later when the seeds had ripened they were removed, taken to the laboratory, where the cotton was carefully picked off, and the seeds planted in damp sand. Poplar seeds need a mineral soil in order to germinate. In rich soils they do not germinate, or if they do the small plants soon die. When the seeds had germinated and the little trees had reached a height of about 2 in., the latter were transferred to larger crocks and separated somewhat from each other.

When the seedlings were 3 to 4 in. high, each one was put into a separate pot, and by the end of the growing season, about the middle of September, they were 5 to 8 in. in height. They were kept out of doors in cold frames through the winter, and the next spring in the field nursery. By September hundreds of these had reached a height of over 5 ft., many 6 ft., and a few 7 ft.

A large number of the hybrids were of course no more vigorous than the parents, but fortunately many grew with greater vigor than either parent.

In their second year rather more than 100 of the best-growing hybrids were reserved and the remainder, nearly 15,000, discarded. Each of these better seedlings was propagated by cutting it up into pieces 10 or 12 in. long, which were stored for the winter. In the spring they were planted in the field nursery, and by the next September each piece had become a tree about 6 ft. tall. The poorer strains were again discarded and the better propagated further.

The studies disclosed that the speed of growth—that is, the weight of wood produced—of the new hybrids is from ten to fourteen times as much per year as the wild poplars growing under similar conditions.

It must not be considered that there is a single hybrid poplar which will be most useful everywhere. The few desirable trees, selected from the thousands grown, were propagated as I have described. Again the best for our purposes were chosen and the remainder discarded, until we have now about 25 "type" trees, which represent some 15 or 20 of the original crosses. It is expected that this number will ultimately be reduced to 6 or 8.

We find that some of the new hybrids grow best in the North, say, in the climate of Maine; some best further south; some grow well on the comparatively dry hilltops, while the most desirable ones require more moisture.

When the hybrids are made by crossing parents which are of quite different character, that is, not at all closely related, they are likely to be far different in their character from either of the parents. For example, the resulting hybrid may be much larger and have more rapid growth than either parent, or it may be a dwarf or have some freak characteristic which we should not expect, judging from its parents. In the present work it is just these last types which are of most value. We want a freak which is exceptionally rapid in growth, which has unusually long cellulose fibers, and a desired habit of growth, that is, form of tree, as well as reasonable freedom from disease. It was such freak individuals picked from the 15,000 hybrid seedlings which have been of most value in this work.

METHOD OF PLANTING AND CUTTING

During the fall or early spring the selected land is burned over to remove weeds, weed trees, and other undesirable vegetation. As soon as the frost is out of the ground the cuttings can be set out. The men work in pairs. One goes ahead with a dibble with which he makes a hole in the ground every 6 ft. The other follows with a bundle of cuttings, places one in each hole, and presses the soil about the cutting with his foot.

Apparently it is not worth while to plow the land previously or to use fertilizers.

At the end of eight or ten years, depending upon the growth, that is, the weather to which they have been subjected, three-fourths of the trees are cut, leaving the remaining trees approximately 12 ft. apart in each direction. These trees continue to grow for another 8 or 10 years, when they will be cut for lumber or pulpwood. The trees cut at the end of the first 8 or 10 years will be amply large for pulpwood, and their removal will mean a real profit to the grower. We expect the trees to yield approximately an inch in diameter for each year they have grown, equivalent to a yield of 80 cords per acre in 12 years. When one compares this with natural reforestation, which yields 6 cords per acre in 60 years, the improvement is clearly seen. In other words, the new poplars grow fully ten to fourteen times as fast as the woods now used for pulpwood. The poplar plantations will bear such dense stands that it will be practicable to build permanent roads and camps, with the result that the cost of cutting per cord will be less than half the cost of cutting pulpwood from ordinary forest lands.

I should be afraid that our proposed plantations of hybrid poplars would suffer in our climate from lack of water if it had not previously been proved how efficient the tree roots are in hunting water. Poplars are notoriously long rooted, and accordingly efficient finders of water. Hence it would seem as if we need not fear but that the supply of water in an ordinary year will be sufficient.

It must be recognized, however, that in a mature tree the top leaves are in a desert and exposed to the hot sun and a drying wind. Moreover, they are farthest removed from the base of water supply. Examination of leaves and stems on the tops of trees shows that they are often different from those lower down in that they have thicker skins, smaller cells, and smaller breathing pores. All these tend to decrease the evaporation of water from the surface of the leaves. Perhaps one reason why the tree does not keep on growing but reaches maturity is because of the difficulty of getting an adequate supply of water from the roots up to the top of a large, mature tree.

PROTECTION BY PATENT

The cost of investigating the hybridization of poplars has been extremely high, not only in actual money spent but in time and effort over a long period of years. It is desirable to know, therefore, what protection one may expect from "pirating" in the future.

New plants and trees can now be patented in the United States. Last year Congress passed a law, and passed it unanimously, which gives the man who produces new hybrid plants the same encouragement and protection that the inventor of new processes and apparatus has received for more than a century. It is the world's first plant patent law.

ADVANTAGES AND HANDICAPS OF HYBRID POPLARS

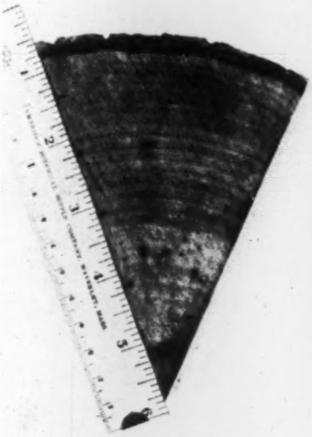
Some additional advantages in growing the new McKee hybrid poplars as an agricultural crop are:

The cost of planting is considerably reduced, as it is only necessary to push a sharpened instrument into the ground, insert the cutting, and compact the ground about the cutting by pressure of one's foot.

The principal requirements for the growth of poplars seem to be water and sunshine; so cut-over hillsides are just as satisfactory for growing hybrid poplars as high-priced bottom farm land.

Due to the density of the growth per acre, careful forestry supervision can be inexpensively given.

Wood is much more compact than farm forage crops. This is an advantage in handling, storage, and protection from decay, as well as in pulp-mill operations.



SHOWING WIDTH OF ANNULAR RINGS OF COMMON POPLAR (*P. tremuloides*)

Timber has a diversified market both as lumber of various sorts and as pulpwood.

The trees can be left growing until wanted. Instead of spoiling like a forage crop they increase in size. It is not necessary to market the wood in a year when the price is low.

Forest plantations protect the country from floods, from erosion of arable land, and tend to increase the rainfall and preserve a more even climate.

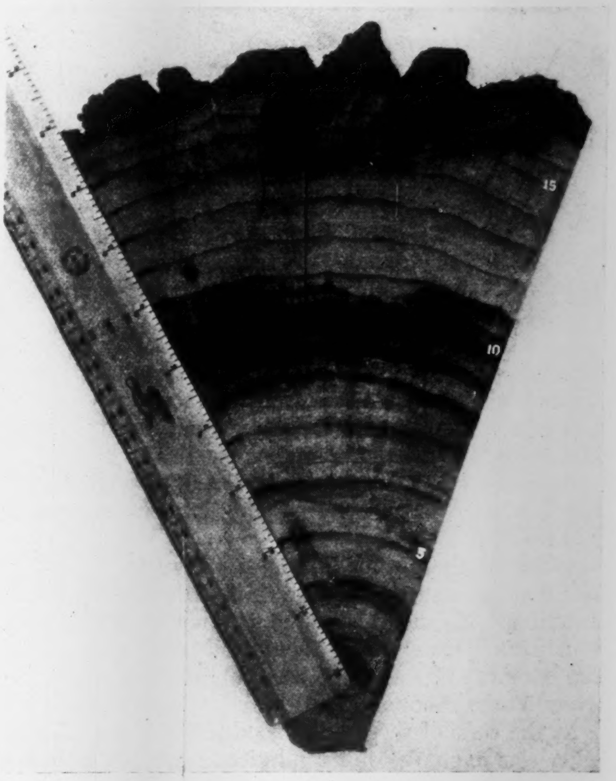
All calculations indicate that there are more dollars of profit per acre-year in growing wood than in growing wheat or other common farm crops.

Some handicaps not previously mentioned are:

Plantations of solid stands are more liable to fire, because if one tree is in a condition to burn readily, all the trees are equally so. This risk, however, is less than in the case of conifers, such as spruce, fir, and the like.

The growth of solid stands of trees increases the susceptibility to insect and fungus pests, for if one tree is susceptible then the others are of the same variety and in the same condition, and accordingly are equally susceptible.

The growth of broad-leaved trees such as poplars requires a large amount of water to take care of the evaporation. Ordinary farm crops require from 200 to 400 lb. of water for each pound of plant produced. As yet we have not made tests to determine the amount of water required per pound of poplar tree, but expect it to be of the same order, say, 300 lb. of water for each pound of plant, or about twice that for each pound of pulpwood produced. This means that the new hybrid poplars will grow well in the growing months of May to August, inclusive, only if during that period we have a rainfall of more than 3 in. each month. It will not do to have this rainfall bunched into a single month. It must be distributed over the season if we are to get maximum growth.



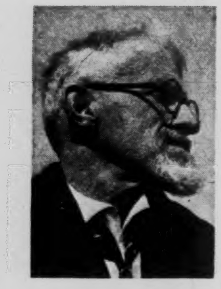
SHOWING WIDTH OF ANNULAR RINGS OF A HYBRID POPLAR
(The best of the new poplars are expected to show rings of still greater width.)

At the start it is difficult to propagate the poplars rapidly, as this has to be done by use of cuttings instead of by seed. A poplar which has grown a single year can, the next spring, be cut up into about 8 cuttings and these planted. The following year we shall by the same process get 64 cuttings and the fourth year about 500, the fifth year about 4000, and the sixth year some 32,000. As it takes about twelve hundred cuttings to plant an acre, it is obvious that several years will be necessary to obtain sufficient cuttings to plant a commercial acreage, say, 1000 acres a year. Means of increasing the present rate of propagation are under investigation, and there appear to be methods which will increase this perhaps five times. Thus in four years we could produce the same amount of nursery stock as in six years by the present method.

The Stagger-Decalage Biplane

An Adjustable-Wing Design of Plane That Lands Safely Without the Manipulation of Controls and, It is Stated, Will Not Nose Dive, Stall, or Spin

By ALBERT A. MERRILL,[1] NEW YORK, N. Y.



THE stagger-decalage biplane comprises two supporting surfaces placed one above the other and one ahead of the other, one of the surfaces always having a greater angle of attack than the other. "Angle of attack" is defined as the angle between the chord of a surface and its air path, and in this article will be designated α.

The particular combination the author has been working with has the top surface ahead of the bottom surface, the front surface always having the greater angle of attack. This combination has static pitch stability: that is, when balanced to fly at a certain angle α, if for any reason α is changed, a couple is produced which tends to return the ship to the original angle.

As far as the author knows, he was the first to test in flight a stagger-decalage biplane cellule with no stabilizer. He did this in the summer of 1914, first at Squantum, Mass., and then at Marblehead, Mass., and a report of this work was published in *Aeronautics* (New York), September, 1914.

At the time of these first experiments Mr. J. C. Hunsaker was in charge of aeronautics at the Massachusetts Institute of Technology, and after the flights at Marblehead the author urged him to test this combination in the wind tunnel at M.I.T. This he subsequently did, and his results were published in *Engineering* (London), January 7, 1916, under the title "Stable Biplane Arrangements."

In 1918 the author became a member of the faculty of the California Institute of Technology (then known as Throop College), and went on with the work in his leisure time. After building several planes which were flown by different pilots, one was arrived at which satisfied him aerodynamically and its possibilities were demonstrated in the spring of 1926 at Ross Field, Arcadia, Calif., before some of his fellow faculty members. Continuing this development the C.I.T. built a plane which was flown at the Mines Field Meet at Los Angeles in 1928, where it was successful in demonstrating its stable qualities in the air.

Early in 1929 the author resigned from C.I.T. in order to devote his whole time and effort, in cooperation with an engineering organization brought together by Hannibal C. Ford, of the Ford Instrument Company, to the development of a successful commercial plane. The result of this association is the ship publicly demonstrated at the Glenn Curtiss Airport, Long Island, on February 11 of this year.

CHANUTE'S EARLY PREDICTION

In March, 1903, Octave Chanute told the author that the problem of flight would be solved soon either by the Wrights or by the Frenchmen who were working on it, but that he did not like the system of pitch control used by the Wrights. He said in effect: "Their design will always require too much skill and watchfulness on the part of the pilot for it ever to be a safe one for the average man." This was Chanute's opinion stated nine months before the flights at Kitty Hawk that made history. From that day onward the author constantly asked himself, "How can we reduce the amount of skill and coordination required in the pilot to fly and land safely?"

Why is so much skill required in the fixed-wing standard-type design? The author's contention is that this skill is required because in this design the angle of attack α is changed by rotating the whole machine in pitch by means of the elevator. This rotation of a mass in a gravitational field stores up angular momentum, and this momentum carries the ship by the new angle α_1. Now this over control in pitch is a function of the psychology of the pilot, and that is why skill is required and why some persons can never learn to fly a standard design.

Fig. 3 shows typical lift and drag curves for a surface. Point A, called the "burble point," marks the maximum lift. At B the lift is zero. Now these two points are danger points, B producing a nose dive and A producing a stall, with a possible tendency to spin. The normal range for flying lies between C and D, where C is the angle for maximum speed and D is the angle for maximum rate of climb. As long as the angle of attack α stays within the range CD there is no danger from flying, because in this range the plane can neither dive nor stall, and the air speed gives ample roll and yaw control.

The mean of the performance of eighteen planes tested by the U. S. Navy Department is shown in Fig. 4. From this it can be seen that there is no reason why, in normal flying, α should approach anywhere near A or B, yet it does frequently. Why? Because of the psychology of the pilot which causes him to *over* control in pitch (unconsciously, of course), the angular momentum in consequence of this forcing α up or down to either A or B.

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[1] Merrill Aircraft Company.

Presented at a meeting of the Metropolitan Section of the A.S.M.E., New York, February 25, 1931.

STAGGER-DECALAGE CONSTRUCTION PREVENTS OVER CONTROL OF PITCH

The stagger-decalage biplane combination being used in the latest plane of this type has 45 per cent positive stagger and 4 deg. positive decalage (Fig. 5), and this biplane cellule alone considered as a single rigid supporting surface with no stabilizer, has excellent static pitch stability. If now this rigid biplane cellule is mounted on a fuselage so that it can be rotated mechanically about the point O, then by so rotating it we can change and fix α without creating any angular momentum since the fore-and-aft axis of the fuselage always travels practically parallel to the air path regardless of the change in α. If also we set material limits to said rotation we can then hold α to any desired angle within the limits CD; and since this motion is an internal one, an instrument can always tell us what this setting means in terms of angle of attack (relative to the air path) whatever the visibility may be, and this without any previous training on the part of the pilot. It is the author's contention that this design prevents *over* control in pitch, which in his opinion is the cause of most accidents in the air.

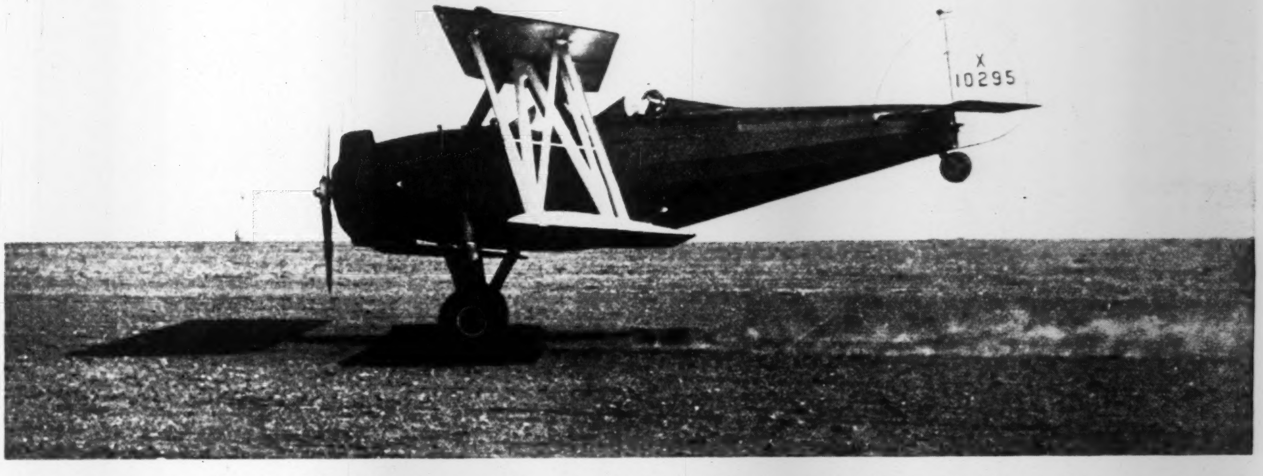

FIG. 1 THE STAGGER-DECALAGE BIPLANE—LANDING WITH PILOT'S HANDS OFF CONTROLS, WITH TAIL UP AND ELEVATOR FLOATING. WINGS AT MAXIMUM SETTING PROPER FOR LANDING

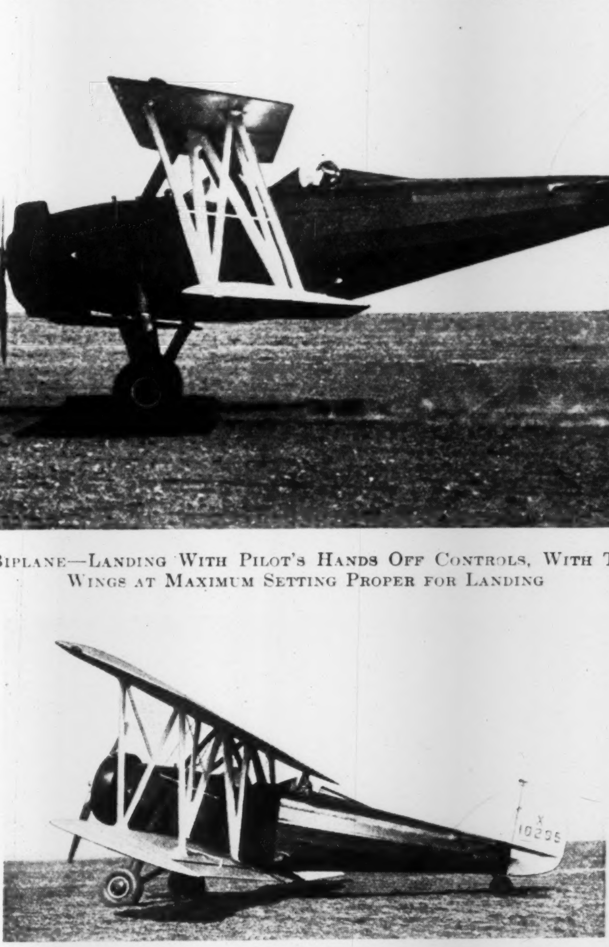

FIG. 2 ANOTHER VIEW OF THE STAGGER-DECALAGE BIPLANE. WINGS AT MAXIMUM SETTING FOR LANDING

With the standard type of plane the proper coordination of eye and muscles for a safe landing is one of the hardest things for the average man to learn, and failure to accomplish this makes it impossible for many persons to learn to fly safely. The author contends that this also is due to *over* control in pitch, either one way or the other, while approaching the ground. With the standard type of plane it is necessary to level out at just the right moment before ground contact, but with the design in question, leveling out is unnecessary. In that plane when the pilot desires to land but is still high in the air, the wings are rotated to their maximum setting relative to the fuselage, which gives them an angle of attack of 14 deg. and the plane is then simply steered to the ground. At an angle of attack of 14 deg. the lift-drag ratio of the whole plane is such that the path angle relative to the ground is 8 deg. Traveling along this path with the engine throttled down, the plane has of course a certain amount of kinetic energy. Upon contact with the ground, a portion of this energy represented by MV_S^2 (where V_S is the velocity component downward) is completely absorbed by a long-throw oleo landing carriage without shock to the fuselage. The contact is made of course with the tail wheel in the air. The downward movement of the center of gravity behind the front-wheel contact points causes a rotation of the whole ship about the wheel axles, and this sets the tail wheel on the ground and raises the angle of attack of the top surface to 27 deg., creating a high drag, which drag acts as a force holding the tail down. As soon as the tail wheel touches the ground the front-wheel brakes are put on hard and absorb the MV_F^2 (V_F being the forward component of velocity), with no tendency to nose over owing to the rearward position of the center of gravity.

Remember also that at 14 deg. angle of attack for the top surface the slope of the lift graph for the stagger-decalage biplane is such that stalling or tail spin will not take place. See Fig. 6. Landing is merely a matter of steering and of putting on the brakes after contact, no use of the elevator for leveling out is necessary. The problem of landing is not an aerodynamical one at all but the problem of absorbing the kinetic energy of one mass moving relatively to another mass. All that is necessary is a proper undercarriage designed to absorb $M V_S^2$ and MV_F^2 with the least shock and in the shortest time. In the author's opinion the current belief that a very low air speed upon landing is necessary for safety is a popular delusion. The minimum safe speed in the air must always be high enough to make it certain that the pilot and not the wind has control at all times. How safe would one be in a boat on a lee shore without steerage way?

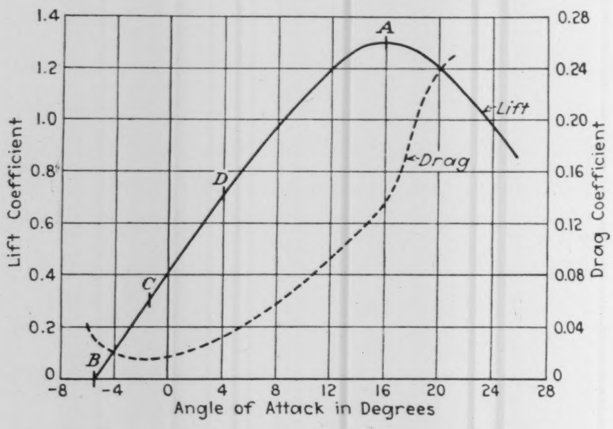

FIG. 3 TYPICAL LIFT AND DRAG CURVES FOR A SURFACE

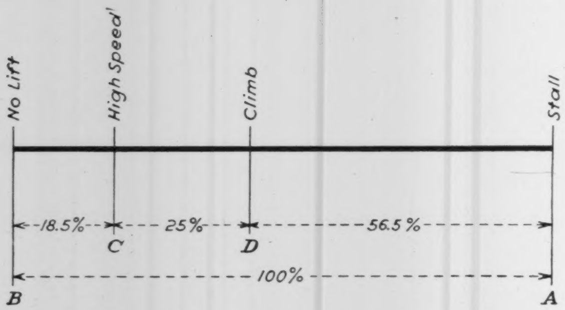

FIG. 4 MEAN OF PERFORMANCE OF 18 PLANES TESTED BY THE U. S. NAVY DEPARTMENT

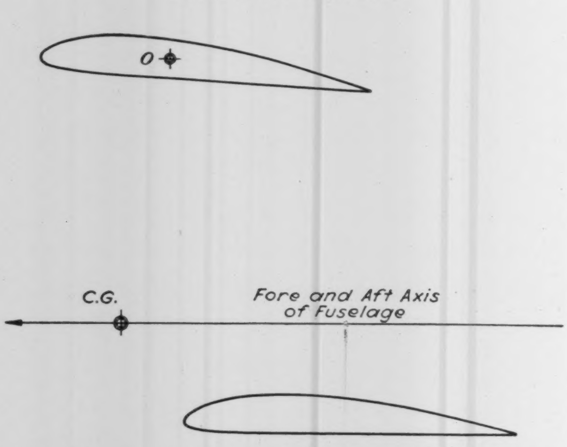

FIG. 5 MOUNTING OF STAGGER-DECALAGE BIPLANE CELLULE ON FUSELAGE

Another great advantage of the design described is the fact that the mechanical setting of the wings, requiring of course no skill, fixes the angle of attack and the r.p.m. of the motor determines the flight path, in consequence of which a pilot does not need any visible horizon to know that his plane is flying as it should fly. He has only to steer it and control it in roll.

Since pitch control determines indirectly, through speed, both yaw and roll control, and since the new design has eliminated the need of training for pitch control, the author feels that it constitutes a real advance in the art.

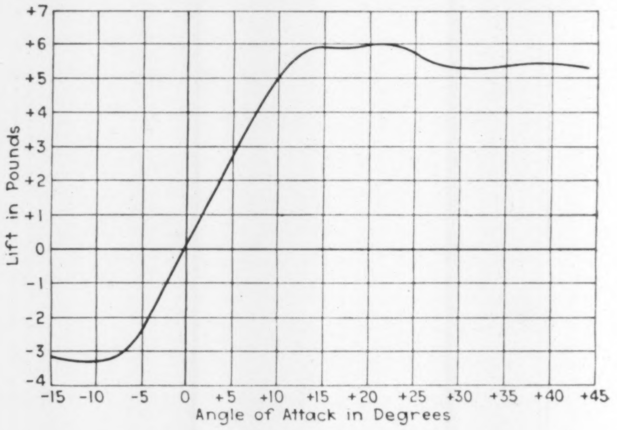

FIG. 6 LIFT GRAPH OF STAGGER-DECALAGE BIPLANE

(Biplane M-12. Gap/chord ratio, 1.1; decalage, + 4 deg.; stagger, + 45 per cent; speed, 40 m.p.h. Tested at N. Y. U., Dec. 9, 1930.)

Brittleness Measurement

THE tension test today is accepted by engineers as furnishing satisfactory and fundamental indications of the quality of structural material. At times it is supplemented by the Brinell and Rockwell tests, and where shock-absorbing information is desired, impact tests on notched specimens are widely used. Tension tests are used to obtain elastic limit, proportional limit, yield point, ultimate strength, elongation, and reduction of area. Latterly there has been disagreement as to the interpretation of these tests. The value of the last two as a measure of ductility is being challenged. Ultimate strength has been found to be only an approximate measure of the cohesive strength of brittle materials. When the yield point is raised even slightly to approach the ultimate strength, loss of toughness may be expected. In a normally tough material brittleness will immediately develop if ability to withstand tearing and resistance to shear are reduced even by a small amount.—R. L. Geruso in *The Iron Age*, Feb. 26, 1931, p. 692.

The Cottonseed-Oil Industry

Its History, Economics, Processes, and Problems

By E. L. CARPENTER[1] and LEO HOLDREDGE,[2] KNOXVILLE, TENN.

IT IS COMMON to think of cotton oil as a recently developed product; however, the vegetable-oil industry is almost as old as civilization. Something of the value of the oil extracted from the cottonseed may be appreciated by the fact that it is rapidly replacing olive oil, whose praises have been sung from time immemorial.

Leo Holdredge

E. L. Carpenter

Tompkins, in his book "Cotton and Cotton Oil," states that the first cotton-oil mill was built at Natchez, Miss., in 1834. However, L. N. Geldert, editor of *Cotton Oil Press,* who has been for many years associated with the National Cottonseed Products Association, and who is probably the best-informed man in the United States on the subject, states that, although it is not a matter of general knowledge, cottonseed oil was produced in this country as early as 1790.

In 1847 a Mr. Martin built and operated a cottonseed-oil mill at New Orleans. After 1847 very little was done with cottonseed until the close of the Civil War.

In 1869 Gen. E. P. Alexander built an oil mill at Columbia, S. C. Other mills quickly followed, and by 1875 the business of crushing cottonseed was definitely established.

In 1875, from a total production of 1,687,000 tons of cottonseed, 84,000 tons were crushed, with a resultant oil yield of 25,275,000 lb., which had a total valuation of $1,590,000. The meal yield for the same year amounted to 30,000 tons and was valued at $940,000.

Government reports indicate that up to the beginning of the present century the values of cottonseed products were calculated on the basis of the oil and meal yield only, no mention being made of any other product.

In 1900, from a production of 4,668,000 tons of seed, 2,479,000 tons were crushed, the amounts and valuations of the products for this year being as follows:

Oil, 699,975 lb., valued at $21,390,000
Meal, 884,000 tons, valued at $16,030,000
Hulls, 1,169,000 tons, valued at $3,190,000
Linters, 114,544 bales, valued at $1,800,000.

In 1925, 6,051,000 tons of cottonseed were produced and 4,605,227 tons were crushed. This crush produced 1,403,781,177 lb. of oil valued at $126,665,000; 2,125,618 tons of meal valued at $79,173,000; 1,330,764 tons of hulls valued at $13,749,000; and 857,962 bales of linters valued at $21,268,000.

The data for 1930 are as follows: Tons of seed produced, 6,590,000; crushed, 5,015,714 tons; oil, 1,572,321,675 lb. valued at $114,892,000; meal, 2,231,992 tons valued at $82,296,000; hulls, 1,383,597 tons valued at $12,103,000; and linters, 1,038,170 bales valued at $20,149,000.

It should be noted in this connection that these figures were compiled at the end of the crushing season and refer to the crop of the previous year.

Figs. 1 to 5, inclusive, show the development of the cotton-oil industry from the year 1875 up to the present time.

Economics

In discussing the economic status of cotton-oil milling the authors will give as few figures as possible consistent with conveying a fair impression of this great industry.

The cotton-oil mills of the United States represent an invested capital of around $200,000,000, and their products are valued at $250,000,000 annually.

At the present time there are 551 active cotton-oil mills having a total of 2731 presses, or their equivalent, in the ten principal cotton-producing states of the country.

If these presses were to operate at their generally accepted capacity of 15 tons per day, in a 300-day crushing season they would handle 12,389,500 tons of seed.

According to the Bureau of Census figures for the three years 1927 to 1929, inclusive, the average annual crush was 4,700,253 tons. Had all mills operated at

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[2] Deceased. Late Assistant Professor of Mechanical Engineering, University of Tennessee. Assoc-Mem. A.S.M.E. Professor Holdredge, a native of northeastern Ohio, received his education at Tennessee Wesleyan College and the University of Tennessee, and held the degrees B.S. and M.S. in M.E. from the latter institution. Prior to entering the teaching profession he was engaged for several years in the hardware business in a managerial capacity.

Presented at the Semi-Annual Meeting, Birmingham, Ala., April 20 to 23, 1931, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

full capacity, only 115 days, or 38 per cent of the actual time, would have been required. Quoting from the "Economic Survey" conducted by the National Cottonseed Products Association, "here is an indicated overcapacity of 62 per cent."

Fig. 6 will give a better conception of the time required to crush the average annual crop for the period from 1927 to 1929, inclusive.

The data given above indicate a press capacity of 4500 tons per year per press. It is contended that this figure, while ideal, is impractical; hence for general purposes the annual capacity per press is usually considered as 3500 tons.

TABLE 1 COTTON-OIL MILLS. AVERAGE OPERATING RESULTS PER TON FOR EACH OF NINE STATES AND FOR TEN STATES COMBINED

	State									Ten states
	1	2	3	4	5	6	7	8	9	
Season of 1927-1928										
Mills reporting	16	26	28	24	94	19	12	32	12	272
Presses represented	86	149	120	110	515	146	79	211	92	1,571
Average presses per mill	5.4	5.7	4.2	4.6	5.5	7.7	6.6	6.6	7.7	5.8
Tonnage represented	204,645	245,598	215,640	165,766	1,002,146	238,689	121,126	418,875	155,904	2,834,224
Average tonnage per press	2,380	1,648	1,797	1,507	1,946	1,635	1,533	1,985	1,695	1,804
Cost of cottonseed (delivered at mill)	$45.37	$45.72	$45.34	$45.20	$41.51	$45.03	$42.58	$46.10	$46.47	$44.02
Current expense	4.94	4.91	5.05	5.26	4.23	4.87	4.68	4.66	4.71	4.64
Fixed and general expense	3.47	5.04	4.66	4.79	4.07	4.54	4.16	4.66	4.66	4.42
Total conversion cost	8.41	9.95	9.71	10.05	8.30	9.41	8.84	9.32	9.37	9.06
Package expense	1.15	0.92	1.24	1.25	0.69	0.89	0.56	0.62	0.75	0.83
Total cost of products	55.13	56.59	56.29	56.50	50.50	55.33	51.98	56.04	56.59	53.91
Total sales of products	56.50	56.05	56.61	57.77	52.18	55.43	53.41	57.01	57.73	54.90
Gross profit or loss	1.37	0.54[1]	0.32	1.27	1.68	0.10	1.43	0.97	1.14	0.99
Federal tax	0.17	0.07	0.15	0.20	0.25	0.06	0.19	0.17	0.16	0.18
Net profit or loss	1.20	0.61[1]	0.17	1.07	1.43	0.04	1.24	0.80	0.98	0.81
Season of 1928-1929										
Mills reporting	18	29	28	24	98	20	14	32	12	285
Presses represented	109	165	124	114	542	150	87	215	92	1,672
Average presses per mill	6.1	5.7	4.4	4.8	5.5	7.5	6.2	6.7	7.7	5.9
Tonnage represented	217,035	241,363	221,982	166,426	1,104,829	303,625	156,091	470,805	198,873	3,176,899
Average tonnage per press	1,991	1,463	1,790	1,460	2,038	2,024	1,794	2,190	2,162	1,900
Cost of cottonseed (delivered at mill)	$45.70	$44.56	$47.74	$44.76	$40.36	$44.94	$40.74	$45.72	$45.25	$43.37
Current expense	4.96	4.82	4.94	4.76	4.15	4.60	4.60	4.48	4.38	4.47
Fixed and general expense	3.87	5.21	5.13	4.93	3.99	3.93	3.84	4.48	3.81	4.28
Total conversion cost	8.83	10.03	10.07	9.69	8.14	8.53	8.44	8.96	8.19	8.75
Package expense	1.03	0.94	1.12	1.02	0.73	0.85	0.50	0.48	0.66	0.79
Total cost of products	55.56	55.53	58.93	55.47	49.23	54.32	49.68	55.16	54.10	52.91
Total sales of products	54.03	52.20	55.46	53.18	50.66	54.20	51.89	55.88	54.91	53.01
Gross profit or loss	1.53[1]	3.33[1]	3.47[1]	2.29[1]	1.43	0.12[1]	2.21	0.72	0.81	0.10
Federal tax	0.02	0.02	0.01	0.04	0.23	0.06	0.27	0.17	0.13	0.15
Net profit or loss	1.55[1]	3.35[1]	3.48[1]	2.33[1]	1.20	0.18[1]	1.94	0.55	0.68	0.05[1]
Season of 1929-1930										
Mills reporting	19	29	28	24	103	19	14	35	12	291
Presses represented	113	166	124	121	579	148	87	232	116	1,748
Average presses per mill	6.0	5.7	4.4	5.0	5.6	7.8	6.2	6.6	9.6	6.0
Tonnage represented	264,555	278,816	192,582	182,515	893,940	356,128	159,796	624,192	302,238	3,336,515
Average tonnage per press	2,341	1,680	1,553	1,508	1,544	2,406	1,837	2,691	2,606	1,909
Cost of cottonseed (delivered at mill)	$34.71	$32.98	$32.79	$31.99	$37.98	$36.18	$37.64	$36.91	$34.58	$35.95
Current expense	4.44	4.59	4.69	4.44	4.25	4.46	4.75	4.36	4.38	4.41
Fixed and general expense	3.24	4.53	5.50	4.47	4.69	3.62	3.98	3.91	3.44	4.19
Total conversion cost	7.68	9.12	10.19	8.91	8.94	8.08	8.73	8.27	7.82	8.60
Package expense	0.98	0.95	1.11	1.03	0.86	0.85	0.57	0.39	0.51	0.77
Total cost of products	43.37	43.05	44.09	41.93	47.78	45.11	46.94	45.57	42.91	45.32
Total sales of products	44.85	42.83	45.66	43.65	47.19	46.29	46.65	47.21	44.89	46.06
Gross profit or loss	1.48	0.22[1]	1.57	1.72	0.59[1]	1.18	0.29[1]	1.64	1.98	0.74
Federal tax	0.19	0.10	0.22	0.23	0.02	0.17	0.04	0.23	0.24	0.14
Net profit or loss	1.29	0.32[1]	1.35	1.49	0.61[1]	1.01	0.33[1]	1.41	1.74	0.60
Averages for the Three Years, 1927-1928, 1928-1929, and 1929-1930										
Tonnage represented	686,235	765,777	630,204	514,707	3,000,915	898,442	437,013	1,513,872	657,015	9,347,638
Cost of cottonseed (delivered at mill)	$41.43	$40.71	$42.35	$40.37	$40.04	$41.49	$40.12	$42.20	$40.63	$40.92
Current expense	4.74	4.76	4.90	4.80	4.21	4.62	4.67	4.48	4.45	4.50
Fixed and general expense	3.52	4.91	5.08	4.73	4.22	3.97	3.98	4.30	3.84	4.29
Total conversion cost	8.26	9.67	9.98	9.53	8.43	8.59	8.65	8.78	8.29	8.79
Package expense	1.05	0.94	1.16	1.10	0.75	0.86	0.55	0.48	0.62	0.79
Total cost products	50.74	51.32	53.49	51.00	49.22	50.94	49.32	51.46	49.54	50.50
Total sales products	51.23	50.02	52.86	51.28	50.13	51.39	50.40	52.62	50.97	51.10
Gross profit or loss	0.49	1.30[1]	0.63[1]	0.28	0.91	0.45	1.08	1.16	1.43	0.60
Federal tax	0.13	0.06	0.12	0.16	0.18	0.10	0.16	0.18	0.19	0.16
Net profit or loss	0.36	1.36[1]	0.75[1]	0.12	0.73	0.35	0.92	0.98	1.24	0.44

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[1] Denotes loss.

Taking this last figure as a basis, the annual percentage utilization of press capacity for ten states is as follows: Alabama, 51.7; Arkansas, 54.8; Georgia, 42.7; Louisiana, 53; Mississippi, 56.9; North Carolina, 38.8; Oklahoma, 43.3; South Carolina, 40.9; Tennessee, 69.5; and Texas, 48.8.

Need for careful study of all items involved in the cost of production of cottonseed oil is greatly emphasized by the fact that statistics collected by the National Cottonseed Products Association show in 1927-1928 an average profit for 272 mills in the ten principal cotton-growing states of 81 cents per ton of seed crushed. For 1928-1929, 285 mills showed an average net loss of 5 cents per ton, and in 1929-1930 the average net profit of 291 mills was 60 cents per ton.

Table 1 shows cost distribution and other interesting data for the periods of 1927-1928, 1928-1929, and 1929-1930, respectively, as well as the averages of these data for the same period.

"In Table 2 an attempt is made to show the distribution of the total revenue received from cottonseed and its products. This table was constructed by computing for each of the three years the total value of products, total conversion cost, total transportation cost, total mill profit, or loss, on the basis of the corresponding average per ton results shown in cost reports." This statement, as well as Table 2 itself, is reproduced by courtesy of Mr. Earl Haynes, Executive Secretary of the National Cottonseed Products Association. Fig. 7 shows the distribution of total revenue from the sale of oil-mill products for the years 1927 to 1929, inclusive.

PROCESSES

The following discussion of the various processes in the cotton-oil mill is intended to be a general survey. An intensive study of any particular process is beyond the scope of this paper. However, the industry does need a thorough investigation of the various processes in the oil mill, and it is one purpose of the authors' to stimulate such investigations.

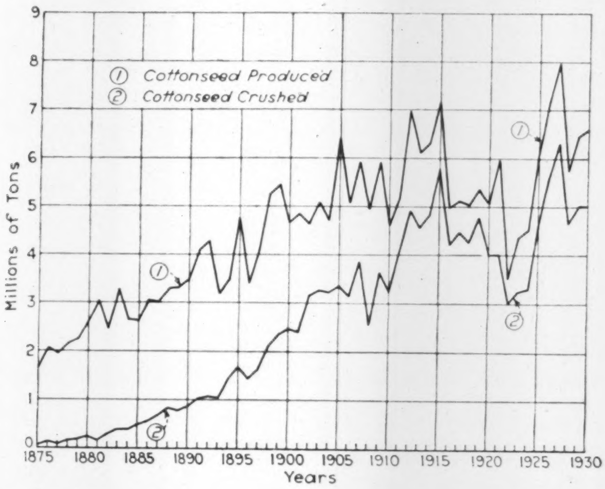


FIG. 1 TONS OF COTTONSEED PRODUCED AND CRUSHED ANNUALLY

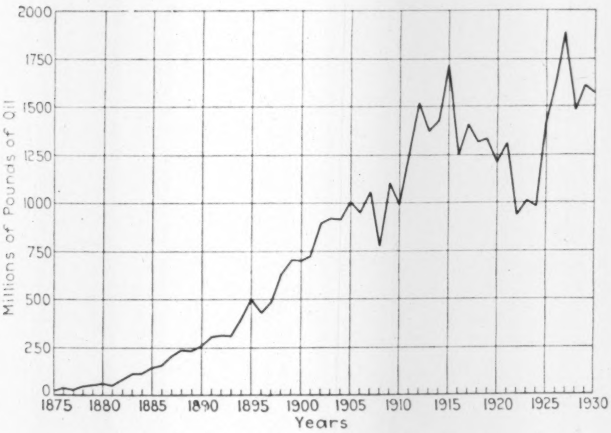


FIG. 2 ANNUAL PRODUCTION OF COTTON OIL

Unloading the Seed. While unloading the seed is not a manufacturing process, it is a material-handling problem worthy of notice. The seed are shipped in box cars. Efforts to unload the cars by the use of pneumatic conveyors have not been completely successful. The seed are often packed so closely that the suction is not strong enough to pick them up as they are received. Other mechanical devices have been tried, but none of them appear to be completely satisfactory. As a result many mills still unload seed by hand.

Sampling. The setting up of definite standards of seed and buying the seed on analysis should become standard practice. Such standards have been developed and satisfactory methods of testing are familiar to oil-mill chemists.

But if these tests are to be of any value, the sample chosen for analysis must be representative of the whole lot. The sand and gravel present tend to settle to the bottom of the car in shipping. If a sample

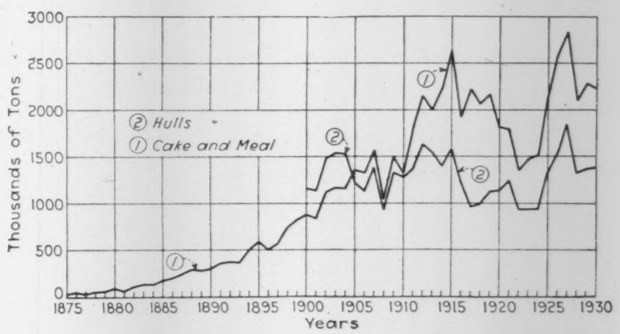


FIG. 3 ANNUAL PRODUCTION OF COTTONSEED CAKE AND MEAL, AND OF HULLS

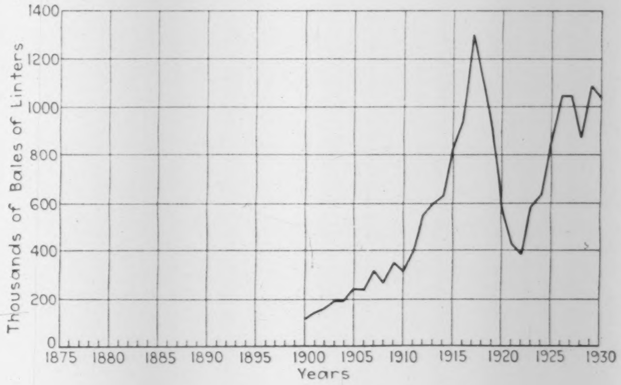


FIG. 4 ANNUAL PRODUCTION OF COTTON LINTERS

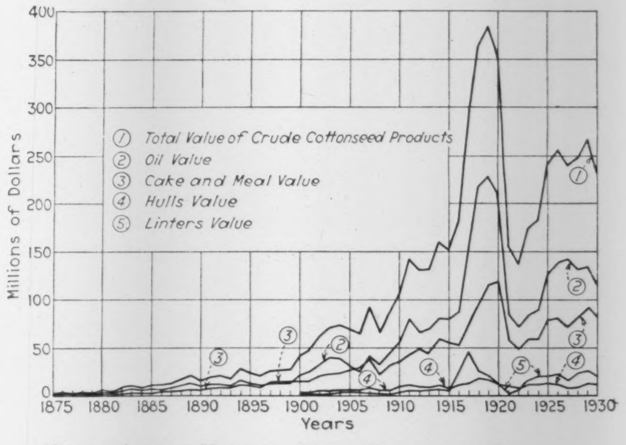


FIG. 5 ANNUAL VALUE OF CRUDE COTTONSEED PRODUCTS

is taken from the top of the car, or from the bottom, it will not be representative.

Precleaning. Often the seed come to the oil mill with an excessive amount of sand, bolls, burrs, and various other sorts of trash. Unfortunately, the ginner seems to put all the trash back into the seed. While this practice is absolutely indefensible, it has been common in the past and is not entirely unknown today.

This condition makes it highly desirable to do some cleaning before the seed are put in storage. The foreign matter is generally a starting point for heating of seed in the warehouse. If this foreign matter is removed before the seed are put in storage, the danger of their being damaged by heating in the seed house is greatly reduced.

But if the seed are to be cleaned between unloading and storage, either the time taken to unload a car must be lengthened or machines of large size used. Either of these alternatives is expensive. A better solution is for the oil mills to demand clean seed from the ginner. This will be better for both the ginner and the oil miller, and should become standard practice.

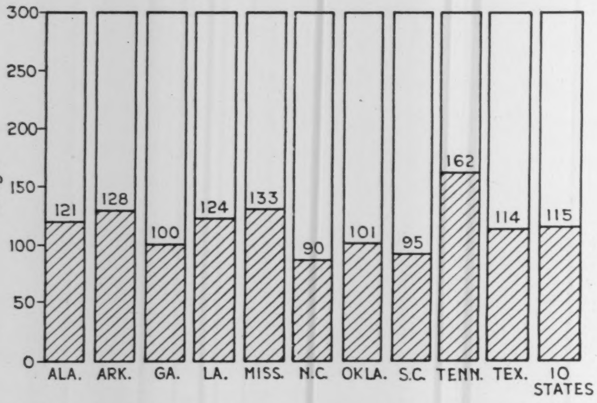


Fig. 6 Chart Showing by States the Number of Days Required at the Rate of 15 Tons per Press per Day to Crush Average Annual Crop, 1927–1929, Compared With an Economical Operation of 300 Days

Storing. The seed are generally received directly from the gin in the late autumn and early winter. This makes it necessary to store some of them for several months.

Storage at some mills is in large concrete, brick, or tile silos. At other mills, sheet-metal sheds are used. Still others use wooden warehouses. All of these have some advantages and some disadvantages.

A good storage system must provide the following:

1 Protection from the weather
2 Provision for drying and cooling seed
3 A conveying system
4 Adequate protection from fire,

and for economic reasons this storage should be provided at a reasonable cost.

The only one of these factors which needs further discussion at this point is the provision for drying and cooling the seed. If the seed are wet they will heat. This causes a very serious loss of quality in the oil and meal.

The cooling of the seeds is done by blowing or drawing air through them. Air ducts are distributed over the floor of the storage house. The seeds are watched closely and, if they begin to heat, air is forced through them. Some of the mills are passing the air over calcium chloride to remove as much of the vapor as possible. This is quite desirable in damp weather, since the drying is as important as the cooling. Dry seed do not heat, but wet seed do.

Conveying. Material handling is quite an item in the oil mill. The seed must be conveyed from storage to the mill. In the mill the seed must be moved from machine to machine. The average mill uses the screw conveyor for these movements. But the many accidents resulting in the loss of life, or of an arm or leg, suggest that a belt conveyor be employed in the interest of safety.

Cleaning. The first process to which the seeds are subjected as they come from storage to the mill is cleaning. This cleaning is much more thorough than was possible when the seed were en route from car to storage.

Since many mills do no precleaning whatever, and much foreign matter is present in the seed in any case, great care must be taken to have the seed as clean as possible before they go to the linter. All dirt and trash which adhere to the seed cause much damage to machines and products.

Linters. The seed come to the oil mill with a considerable amount of short fiber on them. The machines used to remove these short fibers, as are the fibers themselves, are called linters. They are made similar to cotton gins, but are designed to remove most of the short fiber left in the original ginning process. Sometimes the seed are run through two or three linting machines in series. When this is done, the fiber removed is known as first-cut, second-cut, and third-cut linters. The first-cut linters are nearly pure white and the fiber is of fair length. The third-cut is greatly flecked with particles of hulls and the fiber is very short. The number of cuts and the amount of lint removed depend upon the market price for the different grades.

Hullers. After leaving the linters the seed go to the hullers. These may be either of the cylindrical or disk type. The huller is essentially a machine which cuts each seed into two pieces by means of the shearing action between stationary and revolving blades. Good hulling demands that the seed be cut instead of crushed. This means that the knives must be kept sharp. The knives should also be adjusted so that the seed are cut in the center instead of one end's being clipped off.

Separator. After the seed are cut, the next process is to remove the hulls from the meats, as the kernels are called. In the first separation the material is divided into three parts. These are: first, the hulls from which the meats are removed; second, the meats

TABLE 2 DISTRIBUTION OF TOTAL VALUE OF COTTONSEED AND ITS PRODUCTS SHOWING COSTS, MARGINS, AND PROFITS FROM PRODUCERS TO CONSUMERS

		Totals	Per ton		Per cent
Season of 1927-28					
Total tonnage crushed[1]		4,654,017		....	....
Value of manufactured products[2]		$255,505,533		$54.90	....
Deduct:					
Transportation[2]	$ 8,656,472	....	1.86	....	....
Conversion cost[2]	46,865,951[3]	....	10.07[3]	....	....
		55,522,423		11.93	....
Balance available for distribution		199,983,110		42.97	100.00
Amount received by farmers[4]		167,218,831		35.93	83.61
Seed merchants' gross spread[5]		28,994,526		6.23	14.50
Mill net profit[2]		3,769,753		0.81	1.89
Season of 1928-29					
Total tonnage crushed[1]		5,061,058		....	....
Value of manufactured products[2]		$268,286,685		$53.01	....
Deduct:					
Transportation[2]	$ 9,211,126	....	1.82	....	....
Conversion cost[2]	49,041,652[3]	....	9.69[3]	....	....
		58,252,778		11.51	....
Balance available for distribution		210,033,907		41.50	100.00
Amount received by farmers[4]		179,110,843		35.39	85.28
Seed merchants' gross spread[5]		31,176,117		6.16	14.84
Mill net profit[2]		253,053 (loss)		0.05	0.12
Season of 1929-30					
Total tonnage crushed[1]		$5,015,714		....	....
Value of manufactured products[2]		$231,023,787		$46.06	....
Deduct:					
Transportation[2]	$11,385,671	....	2.27	....	....
Conversion cost[2]	47,699,440[3]	....	9.51[3]	....	....
		59,085,111		11.78	....
Balance available for distribution		171,938,676		34.28	100.00
Amount received by farmers[4]		152,828,805		30.47	88.89
Seed merchants' gross spread[5]		16,100,442		3.21	9.36
Mill net profit[2]		3,009,429		0.60	1.75

[1] From report of the U. S. Bureau of Census.

[2] Based on costs and profits reports from over 300 mills.

[3] Includes Federal income tax.

[4] From report of U. S. Department of Agriculture.

[5] This represents that portion of the total value obtained from the sale of cottonseed products which is not specifically accounted for by the amounts received by the farmers, by the mills, by transportation, and by conversion cost, which includes Federal income tax. There remains, therefore, only one other service to account for it—the merchandising of seed from farmers to crushers.

without hulls; and third, those hulls which have meats adhering to them. The last of these are sent to another machine called a beater. As its name implies, this machine beats the meats loose from the hulls. These hulls and meats then go to another separator, or are fed back to the first separator.

In the separator the meats fall through a screen, but the hulls pass over it. As the hulls get to the lower edge of the screen they pass under a suction nozzle. The suction is adjusted so that the empty hulls are lifted off, but hulls from which the meats are not yet separated pass on to the beater.

Crusher. In most American oil mills the meats go from the separator to the crusher. The crusher is a series of rolls through which the meats pass. Here the meats are rolled into very thin flakes in preparation for the cooking process. It does not appear to be definitely known whether many oil cells are actually ruptured or not. Neither does it appear to be known whether actual rupture of oil cells is needed in the crushing.

Cooker. The cooking is done in a steam-heated kettle. The type generally used is the stack cooker, which is a series of steam-jacketed kettles placed so that the meats pass from one section to another immediately below it. Four or five of the sections or kettles are used to each cooker.

Stirring blades are used in the kettles to bring all the meats in contact with the heated surface and to prevent overheating those next to the walls and bottoms of the kettles. Uniform heating is essential for best operation.

The semi-continuous process is commonly used in cooking. The meats from the lower section are removed, and then those in the one directly above are dropped into it through a valve in the bottom of the kettle. In the same way each section is filled from the one above it. An automatic valve is used to regulate the flow into the upper section. The time required for the meats to pass through the cooker varies from 35 to 90 min.

In the common type of cooker no steam is in the meats except that generated from the moisture. The pressure is atmospheric. In one type of cooker superheated steam is admitted to the meats through small holes in the backs of hollow stirring blades. This steam is removed from the top of each section by an exhauster.

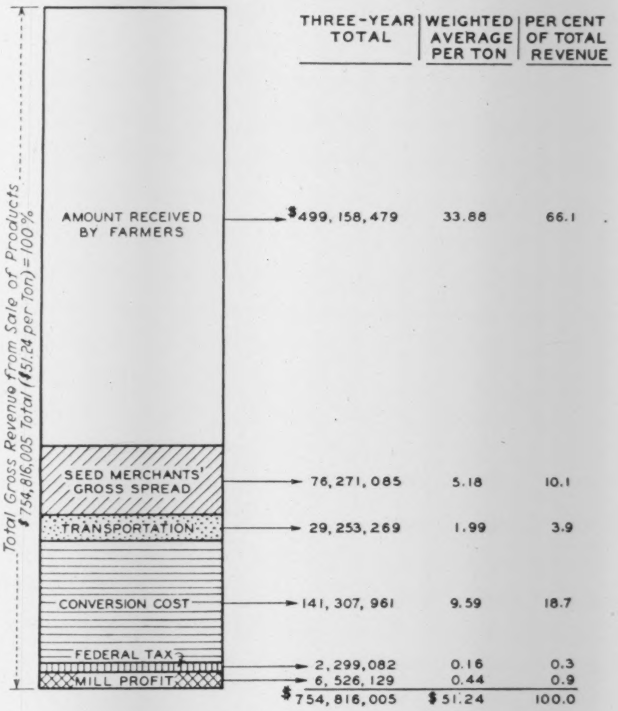


Fig. 7 Distribution of Total Three-Year Combined Value of Cottonseed Products Showing Costs, Margins, and Profits From Producers to Consumers—1927–1929

(Sources of Data: Three-year total of tonnage reported by Bureau of the Census, 14,730,789. Transportation and conversion cost, Federal taxes, and profits based on cost reports of over 300 mills. Seed merchants' gross spread represents the difference between total revenue and total specific amounts shown above.—From an economic survey of the industry made by the National Cottonseed Products Association.)

Former. As the meats come from the cooker they are received by a machine called a former. Here a press cloth is laid in the bottom of the mold in which the cake is formed. An automatically measured quantity of meats is then evenly spread over the mold and the press cloth is folded over the top of the cake, after which the cake is slightly compressed. The cakes are then placed in the presses.

Presses. The oil is extracted by pressing in hydraulic presses. The maximum pressure under the ram is about 4000 lb. per sq. in. The ratio of the size of cylinder to cake is such that the pressure on the cake is about 1500 lb. per sq. in. The presses are connected to the pressure pumps so that the pressure comes on slowly at first. This procedure seems to give better results, and the press cloths have a longer life. The presses are allowed to stand under the high pressure for a few minutes to allow the oil to drain.

Expeller. A device called an expeller has been recently developed for the extraction of cotton oil without the use of the common press-room equipment. Owing to its high initial cost, and a feeling of uncertainty about it among mill managers, it has not been widely used. However, great claims are made for the device by the manufacturers.

Cake Cracker and Grinder. The pressure of 1500 lb. per sq. in. on the cakes in the press makes them quite hard. This renders necessary the use of a machine known as a cake cracker to break the cake into pieces small enough to be fed to the meal grinder. The final operation is to grind the cracked cake into meal.

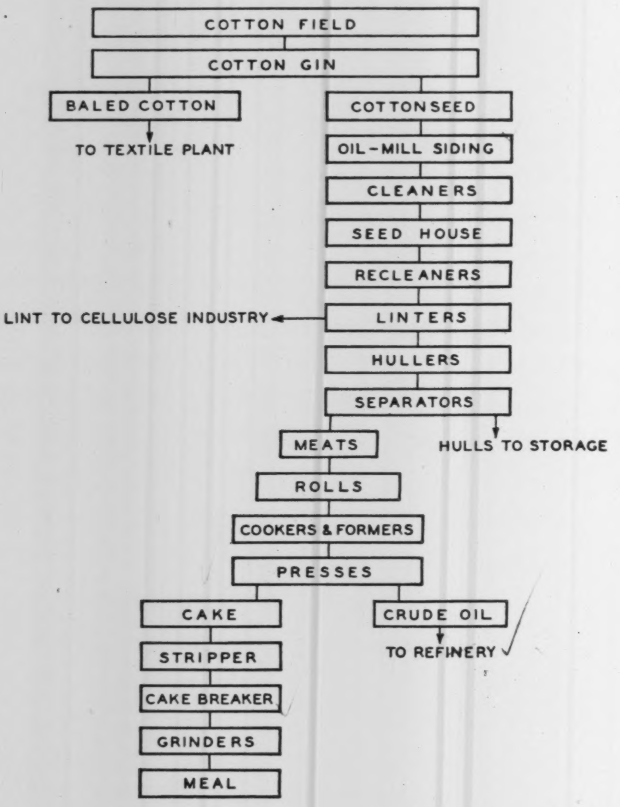

COTTON FIELD
COTTON GIN
BALED COTTON
TO TEXTILE PLANT
COTTONSEED
OIL-MILL SIDING
CLEANERS
SEED HOUSE
RECLEANERS
LINT TO CELLULOSE INDUSTRY
LINTERS
HULLERS
SEPARATORS
MEATS
HULLS TO STORAGE
ROLLS
COOKERS & FORMERS
PRESSES
CAKE
CRUDE OIL
TO REFINERY
STRIPPER
CAKE BREAKER
GRINDERS
MEAL

Fig. 8 Steps in Cottonseed Processing

Fig. 8 is a diagrammatic scheme of the flow of cottonseed through a typical oil mill.

While it is not the purpose of this paper to discuss the refining of cottonseed oil, some idea of the process may be obtained from Fig. 9. However, it must not be inferred from this figure that the products shown represent all the commodities obtained from cottonseed oil.

Fig. 10 shows some of the principal products obtained from cottonseed.

Problems

The cotton-oil industry is facing a number of problems on which research is needed. Some of these have to do with determining the best and cheapest of two or more ways to produce desired results. In other cases the fundamental principles involved need to be established.

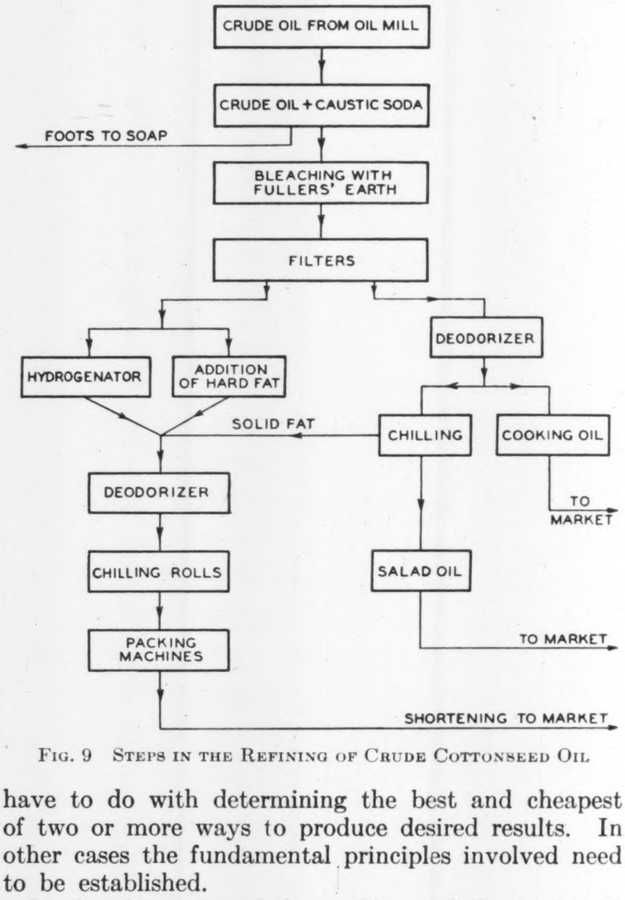

CRUDE OIL FROM OIL MILL
CRUDE OIL + CAUSTIC SODA
FOOTS TO SOAP
BLEACHING WITH FULLERS' EARTH
FILTERS
DEODORIZER
HYDROGENATOR
ADDITION OF HARD FAT
SOLID FAT
CHILLING
COOKING OIL
DEODORIZER
TO MARKET
CHILLING ROLLS
SALAD OIL
PACKING MACHINES
TO MARKET
SHORTENING TO MARKET

Fig. 9 Steps in the Refining of Crude Cottonseed Oil

In this discussion of the problems of the cotton-oil mills much might be said on management. Much might also be said on the uses of the products of the mills. Both of these are, in the opinion of the authors, fertile fields for investigation, but are outside the scope of this paper.

Seed Grading. The grading of seed has been a major problem with the industry. The very narrow margin of profit on which the cotton-oil mill operates makes a very small amount of deterioration in the seed a serious matter. If all seed are bought at the same price, the poorer grades and the damaged seed sell for more than they are worth. As a result, the good seed do not command as high a price as they should.

Under the extensive researches of Mr. G. S. Meloy of the United States Department of Agriculture, methods of grading seed have been developed. But the problem still remains to get this grading plan adopted by all the cottonseed industry. The great majority of crushers are anxious to have this standard universally adopted.

Materials Handling. The materials-handling problem begins as the car of seed is received at the mill. The cars need to be unloaded quickly to save demurrage charges. But the unloading should also be done at a reasonable cost.

The conveying of seed from car to storage and from storage to mills needs study. The screw conveyor is extensively used, but in these places it is a hazard to life and limb. Its power demands are rather large for the work done. An unbiased study of the materials-handling situation would help the oil-mill superintendent to know what was best, and he would not then need to merely follow custom or prejudice.

Drying and Cooling of Seed. The loss due to seed's being damaged by heating in storage amounts to many millions of dollars each year. Yet the principle involved is simple. The statement is frequently made that "dry seed never heat." The corollary of this, that "wet seed always heat," is also true. The prevention of loss from heating of seed looks simple, but in the actual mill it is one of the most troublesome problems that the superintendent must face. Drying of seed between car and storage requires much costly equipment, which is expensive to operate. Efforts to dry and cool the seed in storage are not always successful. A thorough investigation of the various methods for preventing seed from damage in storage would help to solve one of the cotton-oil mill's major problems.

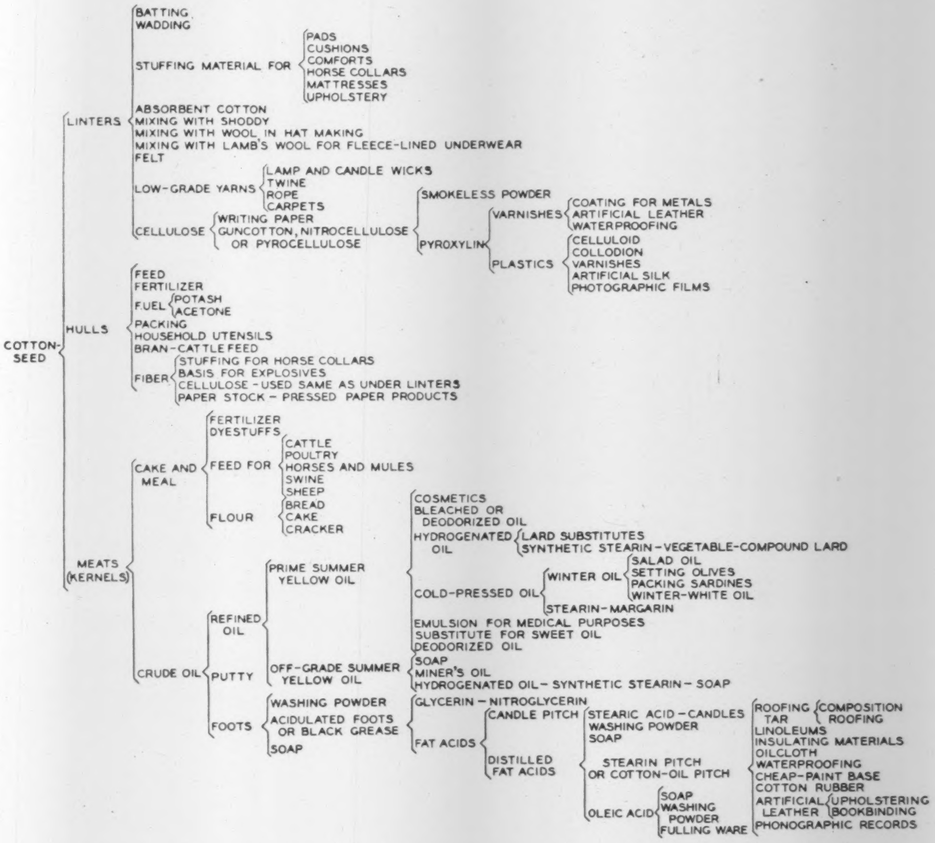

COTTON-SEED
LINTERS
BATTING
WADDING
STUFFING MATERIAL FOR
PADS
CUSHIONS
COMFORTS
HORSE COLLARS
MATTRESSES
UPHOLSTERY
ABSORBENT COTTON
MIXING WITH SHODDY
MIXING WITH WOOL IN HAT MAKING
MIXING WITH LAMB'S WOOL FOR FLEECE-LINED UNDERWEAR
FELT
LOW-GRADE YARNS
LAMP AND CANDLE WICKS
TWINE
ROPE
CARPETS
CELLULOSE
WRITING PAPER
GUNCOTTON, NITROCELLULOSE OR PYROCELLULOSE
SMOKELESS POWDER
PYROXYLIN
VARNISHES
COATING FOR METALS
ARTIFICIAL LEATHER
WATERPROOFING
PLASTICS
CELLULOID
COLLODION
VARNISHES
ARTIFICIAL SILK
PHOTOGRAPHIC FILMS
HULLS
FEED
FERTILIZER
FUEL
POTASH
ACETONE
PACKING
HOUSEHOLD UTENSILS
BRAN-CATTLE FEED
FIBER
STUFFING FOR HORSE COLLARS
BASIS FOR EXPLOSIVES
CELLULOSE - USED SAME AS UNDER LINTERS
PAPER STOCK - PRESSED PAPER PRODUCTS
MEATS (KERNELS)
CAKE AND MEAL
FERTILIZER
DYESTUFFS
FEED FOR
CATTLE
POULTRY
HORSES AND MULES
SWINE
SHEEP
FLOUR
BREAD
CAKE
CRACKER
CRUDE OIL
REFINED OIL
PRIME SUMMER YELLOW OIL
COSMETICS
BLEACHED OR DEODORIZED OIL
HYDROGENATED OIL
LARD SUBSTITUTES
SYNTHETIC STEARIN-VEGETABLE-COMPOUND LARD
COLD-PRESSED OIL
WINTER OIL
SALAD OIL
SETTING OLIVES
PACKING SARDINES
WINTER-WHITE OIL
STEARIN-MARGARIN
EMULSION FOR MEDICAL PURPOSES
SUBSTITUTE FOR SWEET OIL
DEODORIZED OIL
PUTTY
OFF-GRADE SUMMER YELLOW OIL
SOAP
MINER'S OIL
HYDROGENATED OIL - SYNTHETIC STEARIN - SOAP
FOOTS
WASHING POWDER
ACIDULATED FOOTS OR BLACK GREASE
SOAP
GLYCERIN - NITROGLYCERIN
FAT ACIDS
CANDLE PITCH
DISTILLED FAT ACIDS
STEARIC ACID - CANDLES
WASHING POWDER
SOAP
STEARIN PITCH OR COTTON-OIL PITCH
ROOFING TAR
COMPOSITION ROOFING
LINOLEUMS
INSULATING MATERIALS
OILCLOTH
WATERPROOFING
CHEAP-PAINT BASE
COTTON RUBBER
ARTIFICIAL LEATHER
UPHOLSTERING
BOOKBINDING
PHONOGRAPHIC RECORDS
OLEIC ACID
SOAP
WASHING POWDER
FULLING WARE

FIG. 10 VARIOUS COTTONSEED PRODUCTS AND THEIR USES
(Courtesy of National Cottonseed Products Association.)

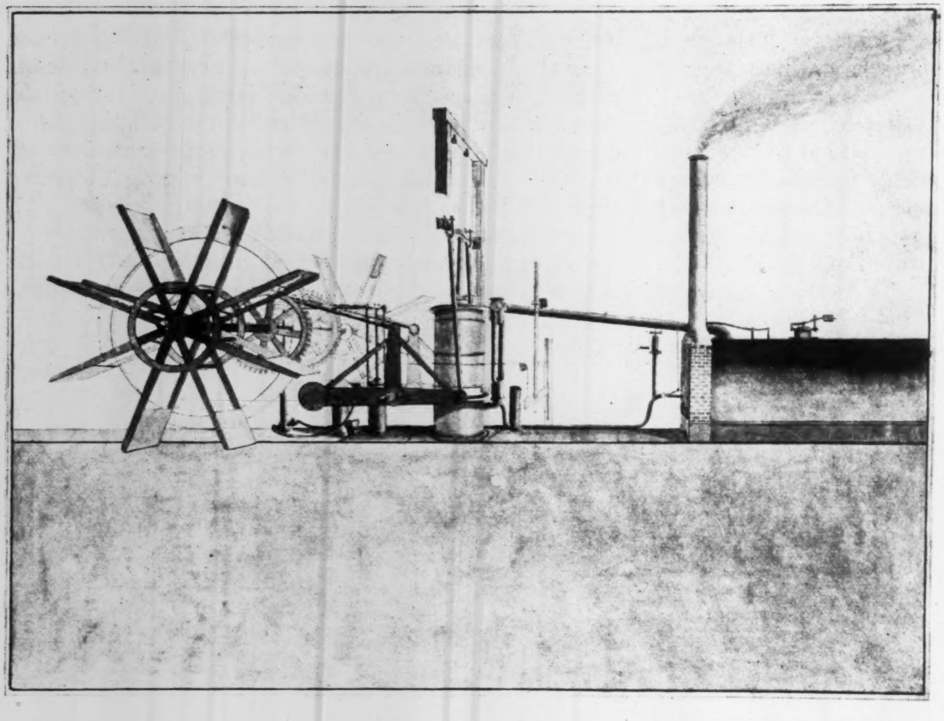
Power. The oil mill is a large user of power. Many engineers think that the amount of power used is larger than it should be. A study of the present machines operating under average and best conditions would enable the superintendent to know if he was using too much power.

Extraction of Oil. In the problem of extracting oil certain fundamental principles need to be determined. What should occur in the crushing of the meats? How long and at what temperature should the meats be cooked? How much moisture should the meats contain as they enter and leave the cooker? What effect does the temperature of cooking have upon the yield and quality of oil and meal? Would steam-heated presses produce better results than the plain presses now used? If so, at what temperature should the steam be? Or are the present methods employed in crushing, cooking, and pressing all wrong? Other methods are available. When the "expeller" is used, what effect does it have on cost of production, and on quality and quantity of products? Or is it a fact that the mechanical method of oil extraction is inferior to some processes of chemical extraction?

The problems here mentioned are not the only ones that the cotton-oil industry faces, but they are some of the most important. An unbiased investigation of the problems of the cotton-oil mill would undoubtedly prove to be of inestimable value to one of the basic and major industries of the South.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to the members of the Tri-State Cottonseed-Oil Mill Superintendents' Association and the National Cottonseed Products Association for their splendid cooperation and assistance in securing the data presented in this paper.



One of Robert Fulton's U. S. Patent Specifications

Robert Fulton's Patent Drawings

A VALUABLE set of Robert Fulton's patent drawings was recently discovered in London when the offices of *The Engineer* were being moved to a new location. These drawings have now come to this country as the gift of *The Engineer* to The American Society of Mechanical Engineers. In a letter announcing the discovery of the drawings and offering them to the A.S.M.E., Mr. Loughnan St. L. Pendred, editor of *The Engineer*, wrote as follows:

"When we were moving offices a few months ago, a collection of old drawings was discovered among some forgotten papers.

"I submitted the drawings to Mr. H. W. Dickinson, and at once heard from him that the collection was a wonderful and wholly unexpected find. The drawings are, in fact, copies of the original drawings made by Fulton for his Patent Specification, and the whole history of them with which you are probably familiar, is given in the enclosed memorandum which Mr. Dickinson has drawn up for me. They are also reproduced and discussed in Mr. Dickinson's life of Fulton.

"Our Chairman—Sir Gerald Chadwyck-Healey—gave me permission to dispose of the drawings as I thought best, and after careful consideration, I have decided to present them to your society as a recognition of the many kindnesses received from its staff and members.

"There was, you will recall, one collection of these drawings in the United States, but it was destroyed some years ago in a fire which consumed many State papers, and I believe I am right in saying that, if your Society will accept this gift, it will be in possession of the only set in Fulton's own country, and one of the three sets that are known to exist."

The memorandum by Mr. H. W. Dickinson, Honorary Secretary, The Newcomen Society for the Study of the History of Engineering and Technology, and author of "Robert Fulton: Engineer and Artist," referred to in Mr. Pendred's letter, follows.

Memorandum on the Drawings

"The drawings herewith were found with other papers in the offices of *The Engineer* in the spring of this year when removing from 33 Norfolk Street to the new premises. How long they had been in the office or where they came from is not recorded, but an explanation is suggested below. They bear no marks of identity except the name of the draughtsman 'J. Kearney;' the watermark is 'J. Whatman 1794' and 'T. G. & Co.'

"On examination they turn out to be the drawings of Robert Fulton's United States Patent Specifications of 1809, Feb. 11th, and 1810, Oct. 2nd, for his steamboat. Furthermore these drawings are with little doubt those which Fulton entrusted in 1811 to Joseph C. Dyer (1780–1871), a compatriot favorably known in England as an inventor, for the purpose of pushing the steamboat in this country.

"Mr. Dyer says:[1] 'I undertook, in 1811, the task of inducing some of the leading engineers and capitalists of London to engage in the introduction of steamboats, on Fulton's plan, to run on the Thames and other waters in this country. Believing that they must soon be adopted and become of great importance to England, as they were so rapidly becoming in the United States, I had obtained from Mr. Fulton (through a mutual friend), a full description and drawings of his inventions and discoveries relating to steam navigation, with the result of his labours in America. But I found it impossible to convince any of them that steamboats could be made to run with safety and profit in the English waters.' The general reply was, 'We don't doubt the success of steamboats in the large American rivers and inlets from the sea, but they will never answer in our (comparatively) small rivers and crowded harbours.'

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[1] In a paper, "Notes on the Introduction of Steam Navigation," read before the Manchester Literary and Philosophical Society, February 10, 1862, and printed in the Memoirs, 3rd. ser., 1865, ii. 292.

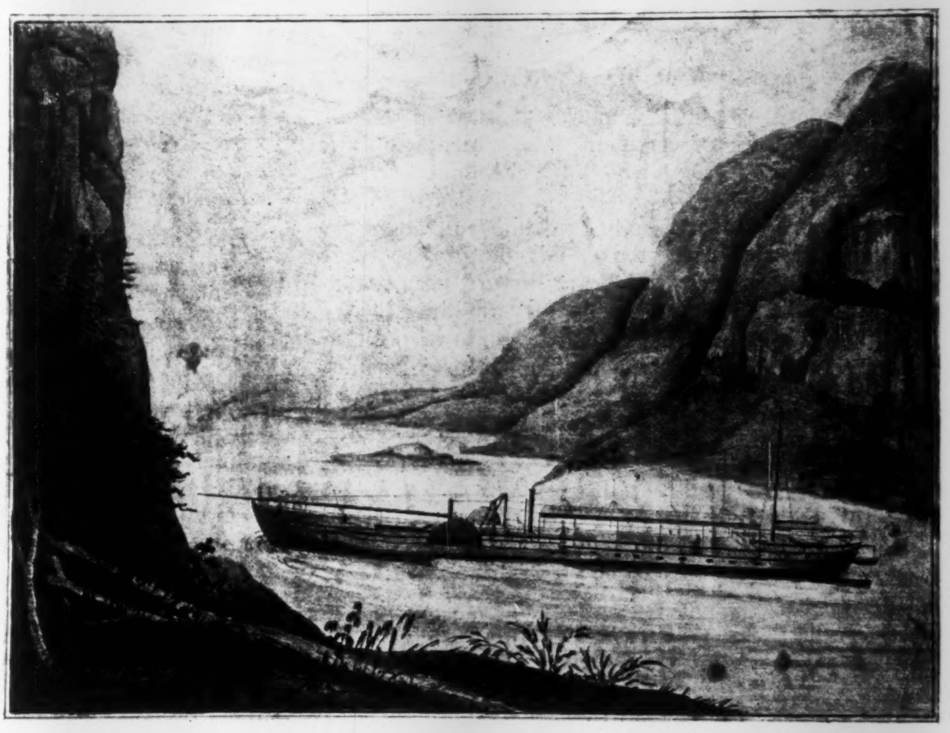
"Dyer goes on to say that he was dissuaded by personal friends and distinguished engineers from wasting his 'time and money on so hopeless a task as that of introducing steam navigation into England.' Mr. Peter Ewart, a well-known engineer and personal friend of Dyer who had been employed by Boulton & Watt on the erection of Soho Foundry, in 1814 borrowed the drawings 'which were sent by him to Boulton & Watt and returned to me about six months after. I have reason to believe that eminent house was led thereby to make further and more exact enquiries concerning the progress of steam navigation in America, for they, as well as several other engineers, commenced building steamboats in 1815 and 1816.'

"Dyer's paper was reproduced in *The Engineer*[2] with a woodcut of the *Clermont*, taken obviously from the frontispiece of the set of drawings, and the inference is clear that Dyer sent the drawings to the Editor (who, by the way, was a friend of his) for the purpose of preparing the illustration. The woodcut appears in the Memoirs, but slightly cut down so that it looks as if the Editor of *The Engineer* had lent it to the Editor of the Memoirs; such a practice is followed today by the present Editor.

"In the Boulton & Watt Collection at the Birmingham Reference Library there are today copies of the drawings and also of the specifications; that these can only have been taken from Dyer's papers is evidenced by the fact that there is a hiatus in both sets, i.e., 'Drawing 12th,' specification of 1809, and 'Drawing 6th,' specification of 1811, are missing. Furthermore in the Patent Office Library there is another copy of a specification with tracings of the drawings, and in these again the same hiatus occur; the latter documents appear to be those obtained from Mr. Dyer[3] by Mr. Bennett Woodcroft, F.R.S., when he was preparing his work on 'The Origin and Progress of Steam Navigation,' 1848. Woodcroft subsequently became Clerk to the Commissioners of Patents, and the documents in question are in the Woodcroft collection that he left to the Library.

"The present set of documents may be looked upon as authorized copies of the originals filed in the U. S. Patent Office, and this gives them a peculiar value because the originals are no longer known to be in existence; there is not much doubt that they perished in the disastrous fire that took place in the U. S. Patent Office in 1836 which consumed so much of value for the industrial history of the United States.[4]

"The Boulton and Watt, and the Patent Office copies of the Fulton specifications and drawings were critically examined and collated in 1912 by Mr. H. W. Dickinson in his "Robert Fulton: Engineer and Artist," and appear in full on pp. 289–325 as Appendix E to that work."



The "Robert Fulton" Passing the Highlands of the Hudson

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[2] Vol. 17 (1864), p. 365.

[3] Woodcroft reproduces in his work much of the text of the specifications together with drawings 8 and 9 as plates.

[4] "Drawing 12th," specification of 1809, is missing, but there is a "Drawing 13th" not mentioned in the text of the specification that does not appear to have any relevance to it. The other missing drawing is "Drawing 6th," specification of 1811. This is stated in the text to show "the manner in which I now rig my boats." It is conjectured that the unnumbered sketch serving as the frontispiece, entitled "View of the Steamboat Passing the Highlands," is the missing drawing.

Atomic Power From the Engineering Standpoint

Evidence That Matter and Energy Are Interconvertible—Possibilities of Conversion Through Synthesis of Heavier Elements From Hydrogen—Another Apparently Promising Line of Attack—Control of the Energy That Might Be Liberated by Synthesis

By LEO G. HALL,[1] DOWNERS GROVE, ILL.

SINCE Einstein's theory, which postulates the equivalence of mass and energy, was given such wide publicity a number of years ago, references to the possibility of obtaining our future power supply from the immense store of energy locked up in the form of matter have been recurring in the technical press from time to time. This comment has necessarily been of a very indefinite and unsatisfying nature since scientific knowledge, at least in so far as it involves the detailed mechanism of change of the one into the other, has been correspondingly meager, and still is so. Evidence bearing more or less directly on the matter has, however, been slowly accumulating from many quarters; and although the question as to the possibility of converting matter into useful energy by controllable means is still far from answer, material for a much more definite discussion of this possibility than has hitherto appeared in the technical press is available. The known fact that a gram of mass is equivalent to about twenty-five million kilowatt-hours in power units cannot fail to make such a discussion of interest to engineers.

Equivalence of Mass and Energy

Before considering atomic power, it may be well to give a brief outline of pertinent developments to date for the benefit of those who have not followed this field closely.

We are probably all familiar with developments establishing the fact that matter is built of structural units known as atoms, which are in turn very stable aggregations of still more elementary building blocks known as protons and electrons, the units of positive and negative electricity, respectively. Most of us are also probably familiar in a general way with Planck's quantum theory involving the atomicity or discontinuity of energy, or action. This theory, with its logical consequences, explains and predicts experience exactly in so many fields that its validity cannot be doubted. It has in fact entered engineering technology in connection with heat radiation and absorption in boilers. Einstein's theory needs no comment here except to say that in 1901, about fifteen years before Einstein, on purely mathematical grounds, postulated the equivalence of mass and energy, Kaufman experimentally showed that electrons traveling at sufficiently high speed experience an increase in their mass depending upon the change in the kinetic energy of their motion. About the same time Nichols and Hull proved experimentally that energy in the form of radiation has inertia, the only criterion we have for defining mass.

By 1915 accumulated astronomical evidence had fixed on the annihilation of matter in the sun as the only sufficient source of the terrific quantity of energy which that body has been radiating out into space for some billions of years. All other possibilities had been successively proved to be hopelessly inadequate. Some years later, Aston made some very accurate measurements of the mass and energy involved in radioactive disintegration, and obtained a very close quantitative confirmation of Einstein's mass-energy relation,

$$E = mc^2$$

in which E is the energy equivalent of mass in ergs, m is the corresponding mass in grams, and c is the speed of light in centimeters per second. The subsequent discovery of cosmic rays, a form of radiation of exceedingly great frequency and penetrating power, which come to the earth uniformly from space in all directions, and their study by Millikan, have developed the strong probability that not only is matter being annihilated in the sun, but the more complex atoms are also being synthetized of elemental protons or hydrogen nuclei in the depths of interstellar space. This view is rendered the more probable by the fact that the principal frequencies of this radiation are those that should be given off, according to the mathematics of quantum mechanics, in the synthesis of the most commonly occurring elements from hydrogen. The radiation represents the small loss of mass incidental to the transformation, amounting to something less than one per cent of the original mass of the hydrogen.

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[1] Mechanical Engineer. Mem. A.S.M.E. Mr. Hall was born in Ohio in 1890 and received his education at Racine College, Trinity College (Arts), and The University of Chicago (Science). He spent three years in the employ of Stone & Webster and subsidiaries on hydroelectric-power-plant construction in Washington, followed by three years of marine and special machinery drawing and design, first with the Seattle Construction and Dry Dock Company, and later independently. In 1915 he became field engineer on plant construction for the General Chemical Company, the first of a series of engagements on industrial plant developments for various manufacturers. For the past few years, he has undertaken private practice in special equipment design and in engineering materials for difficult service, doing some research in the latter field.

The diffraction of electrons by Davisson and Germer, and by Thomson, and that of protons by Dempster in 1929, has shown that these elementary building blocks of matter are themselves constituted of some sort of waves or vibrations, as is radiation. Perhaps stationary waves or nodes is the most accurate description available for electrons and protons. This gives us our first indistinct glimpse of the machinery involved in the equivalence of matter and energy: a very imperfect one, but a real one none the less. Incidentally, the wave structure of protons had already been predicted by Schrödinger, Heisenberg, and others as a mathematical development of the quantum theory—another link in the long chain of events in which the highly abstract mathematics of the new physics and experience support one another.

We now have the double picture of matter and energy, both discrete or non-continuous in structure, both essentially some sort of waves or vibrations in the ether (a word that covereth a multitude of ignorance); yet differing from one another in some respect not understood, but which may perhaps be best described by saying that matter waves are bound, while energy waves are free. More details may be added to the picture any day, but the main outlines seem to be very firmly established.

To know that matter and energy are actually interconvertible, and to know how to go about making the conversion at will are, however, quite different stories. The first thing that occurs to us in considering the latter is that the matter available to us has already survived a far, far more severe milling in the course of the formation of the earth than any we can hope to produce. It must be, for the most part, exceedingly stable in its present form. Conditions in the interior of the sun, where pressure probably approaching a billion pounds to the square inch is evidently forcing electrons and protons into each other, to their mutual "canceling out" and annihilation, are utterly beyond duplication. The only hope of tapping the store of atomic power lies in the direction of taking advantage of the relatively small proportion of mass lost when matter passes from a less to a more stable form. This is akin to what we now do in a far less concentrated manner when we burn coal to generate power.

Aston's work has shown that with the exception of hydrogen, the lightest one, and the radioactive elements at the heavy end of the table, the elements are now in their most stable form. For practical consideration, therefore, all matter except hydrogen and the radioactive elements may be immediately eliminated, since with the exceptions noted, transformations would involve disappearance of free energy rather than the reverse. The limited supply of radioactive matter, together with the extremely small margin of mass lost in radioactive transformations, would not indicate a very large supply of energy available from this source, compared to the world's long-time power demands. Nor have we learned how to hasten or control radioactivity in the slightest measurable degree.

Possibilities of Conversion of Mass Into Energy Through Synthesis of the More Stable Heavier Elements From Hydrogen

At least in the state of present knowledge, it seems, then, that consideration is limited to the synthesis of the more stable heavier elements from hydrogen. From a quantitative view, this source is quite satisfactory. For the supply of this element is so great that, although less than one per cent of its mass can possibly be converted into power by synthesis, this operation on an efficiency one-tenth as great as that obtained in an ordinary power plant would postpone any danger there may be of a power famine to a date some millions of years in the future.

Although we do not know how to make this synthesis, or even know certainly that it is within the range of agencies available in the world, a few considerations and suggestions present themselves that at least indicate directions for further research. The most obvious of these, namely, the condensation of hydrogen atoms into atomic nuclei by pressure, appears on further consideration to be the least promising; for hydrogen atoms have a habit of leaking away between the atoms of other substances, even solid ones, at comparatively moderate pressures. And if such leakage could be prevented, no material is known having nearly the strength to contain the requisite pressure. In the atomic nuclei of the heavier elements, many protons, together with smaller numbers of electrons, are packed together into a space little greater than the volume of a single electron in the free state. Electrons, and possibly protons also, must be highly compressed in the formation of atomic nuclei. This compression is of a very different order from that of materials in bulk, for in the latter case the comparatively empty atoms containing relatively small nuclei at their centers, are merely pushed a little closer together, without evident alteration in the size of their component parts.

A much higher order of force than is obtainable by compression can be obtained by shooting high-speed streams of charged atoms into hydrogen. The technique of producing such streams traveling many miles per second is already well developed, and is doubtless susceptible of much further development. It may be that collisions at sufficiently high speed would cause compression and synthesis, as Rutherford's work has already shown that they produce disintegration of the oxygen and other atomic nuclei. The order of magnitude of the forces involved would be about the same in the two cases. But it is probable that other factors than mere haphazard collision are involved in synthesis. For instance, a specific orientation of each hydrogen atom at the instant of collision might also be necessary. Since the simplest of the heavier atoms contains four hydrogen atoms or protons in its nucleus, it would also probably be necessary for at least four hydrogen atoms to reach the same spot at the same instant to effect combination. In view of the extremely small size of these protons in proportion to their distances apart in even the densest streams, collisions of two of them would be very rare, let alone collisions involving four at one time. Hence the efficiency of such a method must be very low if indeed it is not zero. This tool has, however, been discussed because its further development cannot fail to shed additional light on the whole question of atomic synthesis.

An Apparently Promising Line of Attack

What appears to the author to be the most promising line of attack lies in another direction, being suggested by Millikan's study of the cosmic rays. Millikan concludes, with much reason, that some of the heavier atoms are being spontaneously formed from hydrogen in the intense cold of space, the mass lost thereby coming to us in the form of cosmic radiation. This conclusion seems the more reasonable in view of Onnes' work in producing a temperature within a degree or so of the absolute zero, and studying matter under that condition. Near the absolute zero, properties of substances change in a very suggestive way. The electrical conductivity of the metals, for instance, becomes almost infinite, induced currents in them continuing to flow for hours after the exciting potential has been removed. Specific heats approach zero as the temperature nears the absolute zero. Other equally fundamental changes in the properties of matter take place under that condition. These changes mean one or both of two things: cooling to so low a temperature causes electrons to shrink to a minute fraction of their volume at ordinary temperature, and atomic forces undergo profound change. Modification of forces would naturally follow from a shrinkage in size of electrons, and there is much evidence that the latter does actually occur. Further, this decrease in the volume of the electron is the one *known* condition to be met in synthesis. There may be other conditions beyond the present horizon. Yet as a basis for further research it is reasonable to assume that a sufficient decrease in the size of electrons may permit so close an approach between electrons and protons as to develop a mutual attractive force great enough to hold them in stable union even against the disruptive tendencies of elevated temperatures. While a decrease in the size of protons may equally well occur with extreme refrigeration, that does not need to be postulated, for the proton normally occupies only about one two-thousandth of the volume of a free electron, though nearly two thousand times more massive than the latter.

Parenthetically, it should be mentioned that size or volume as applied to electrons and protons has no absolute, but only a relative, significance. No definite surface can be selected as a boundary surface of one of these units. There is only a gradual, hazy tapering off of intensity of conditions within them to those without, so far as we know.

The technique of approaching to within less than a degree of the absolute zero has been developed by Professor Onnes. Quite likely further refinements can be made to reach within a small decimal of a degree of that limit. The temperature of matter in space must also be at least some small fraction of a degree above nothing. If the conditions of outer space cannot be exactly duplicated in the laboratory, at least they can be approximated very closely. But since the measured properties of matter change much more rapidly the closer the approach to the limit of temperature, it may be that some very narrow margin of unattainable refrigeration will prove to be the final bar excluding us from the condition under which synthesis can proceed. Be that as it may, both the reasoning given and thermodynamic considerations appear to promise more definite knowledge from this field than we have had in the past. And even if that knowledge proves to be purely negative in character, we can feel with an inventor who once remarked to the author after having been shown just why his invention was not feasible, "Well, it's a load off my mind, even to know it can't be done."

Possible agencies that suggest themselves as aids to synthesis in a region of intense cold are suitable electromagnetic fields, mechanical pressure, or streams of protons shot into hydrogen. One of these agencies might furnish the final shove necessary to cause synthesis, should refrigeration alone prove to be insufficient.

Control of the Energy Liberated by Synthesis

One more feature whose discussion may seem somewhat premature at this stage, will none the less be of interest. This is the control of the energy liberated by synthesis, once that has become an accomplished fact. We know from Planck's energy-radiation frequency relationship that the energy so obtained would be in the form of radiation of hundreds of times greater frequency and penetrating power than the hardest X-rays. It would in fact correspond to the cosmic rays already mentioned, which penetrate many feet of solid lead, or correspondingly greater thicknesses of less massive materials. They are gradually transformed to radiations of lower frequency in passing through matter, being ultimately, in all probability, completely converted into heat. Consequently a picture of the atomic-power plant must include a comparatively small synthesis room completely enclosed by massive walls, perhaps fifty feet thick; these walls being honeycombed by an elaborate conduit system carrying a circulating fluid to convey the heat generated within the walls to its point of application. Perhaps reasons of economy would dictate that the whole system be buried deep underground. At any rate, stacks belching black smoke, gigantic coal piles, and ash dumps have no place in the picture.

If the author has succeeded in giving engineers something definite to think about in this rather sketchy survey, its object will have been accomplished.

The Measurement of Sound[1]

SOUND, in general, is the result of mechanical motion set up in the auditory apparatus of the human being and thence transformed in some unknown manner into mental sensations. Seeing that the mental sensations are, so to speak, functions of the mechanical phenomena, it is only necessary for our purposes to consider the latter. Thus considered, sounds are seen to be the result of vibratory motions executed by bodies which are recognized as the sources of sound. It is a matter of experimental observation that when the frequency of this motion is less than about 20 per second, no sensation of sound is experienced. In the same way, when the frequency is greater than about 16,000, sensations of sound are no longer experienced. However, especially gifted persons appear to have hearing capacities which exceed these limits.

DISTINCTION DRAWN BETWEEN MUSICAL TONES AND NOISES

It is customary to classify sounds as either musical tones or noises.

It has been customary to draw a physical distinction between these two divisions by saying that musical tones are the result of periodic, and noises of aperiodic, vibrations. As a matter of fact, however, noises are themselves invariably the results of the simultaneous excitation of some body into a mass of separate vibration forms, each of which is itself periodic, but which, taken in the aggregate and on account of their short duration, the remoteness of the arithmetical ratios of their frequencies one to the other, or the great physical intensities at which they are produced, are translated into sensations lacking the coherence, continuity, and definite pitch value which are the main characteristics of what are called musical tones.

Thus it will be seen that at base the problem of measuring sound is the same problem whether we are dealing with what are called tones or what are called noises. The boundary between the two classifications is very shadowy and vague. The term "noise" possesses connotations much more psychological than physical, and the same comment may be made upon the words "musical tone." Therefore it cannot be said to matter essentially whether the problem is stated to be that of measuring sounds or of measuring noises. For the sake of accuracy, however, we shall say that the problem before us is the development of a standard objective method of measuring sound. The term "objective," we have assumed, means that the method to be developed by us shall, so far as possible, eliminate fallible personal judgment.

The next question is as to what property of sound we are called upon to measure. So far as the class of musical tones as used in the art of music and allied arts is concerned, the values known, respectively, as pitch and quality are measurable by well-known and accurate methods, which do not call for any special study by us. On the other hand, the measurement of loudness presents a problem which has been settled neither in the field of tone nor in that of noise. In the field of tone, which is governed by esthetic considerations, physical methods of measuring loudness have not been considered to be immediately important until recently, when, owing to the development of electrical methods for recording and reproducing musical tone, this question has emerged.

LOUDNESS THE PROPERTY TO BE MEASURED

In the enormously larger field of noises, however, the question of measuring those properties which in general are subsumed under such titles as intensity, loudness, or noisiness is of the first importance. Thus in the study of vibrations set up by machinery the musical properties of pitch and quality take on an engineering importance, and to that must at once be added the study of loudness as heard by human beings. Also, in the study of machinery noises, after engineers have determined the questions arising from the interaction of moving parts and of sonorous vibrations set up therein, they are called upon to consider the loudnesses of the sounds which they have been studying from a purely mechanical standpoint. This is because the physiological and psychological effects produced on human beings by machinery noise can no longer be ignored in the present temper of public opinion. The Committee has therefore perceived from the start that its object must be to develop an apparatus and a scale to measure heard · loudness objectively. In other words, its business is to find some way of obtaining an expression, which can be registered mechanically, of these various properties, namely, the frequency or frequencies, the number of elements entering into the complex, and the physical intensities with which the elements are expressed.

As can readily be seen, the loudness of a sound appearing as a mental sensation is a result, somehow produced, of a complex of physical events. To take a simple case: if one strikes with the flat of the hand as many of the white keys on a piano keyboard as can be actuated simultaneously in that way, he obtains a result which any observer will denominate a noise. When, however, the opportunity presented by this particularly favorable occasion is taken to analyze the components of the noise, it will be found that the complex is made up of perhaps eight or ten main individual sounds, each known as a musical tone and each producing by itself a mental sensation of definite pitch value. When the analysis is pressed further, it is found that each of these eight or ten main individual sounds itself consists of a greater or smaller number of components. Each of these components is a simple sound, answering to a definite frequency and evoked on this occasion at some definite loudness value. In the particular case under consideration, a hundred separate single tones might thus be combined into a single noise. From that noise the ear obtains no definite pitch sensation, and certainly no definite sensation corresponding to what we call tone quality: that is to say, that characteristic of musical sound which varies according to the manner in which the simple sounds in a complex musical tone are distributed. That which strikes the human hearer of this noise is its loudness value, although this value in the case under consideration arises out of several dozens of simple musical components.

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[1] From a report made November 20, 1930, to the Main Research Committee of the A.S.M.E. by a special committee appointed to investigate the subject and consisting of William Braid White, *Chairman*, Paul H. Bilhuber, Robert L. Davison, F. A. Firestone, E. E. Free, James A. Jackson, C. R. Hanna, R. V. Parsons, H. S. Read, Paul H. Sabine, J. C. Steinberg, Wallace Waterfall, and Irving Wolff, with Messrs. J. L. Alden, E. B. Dennis, Jr., J. P. Foltz, Alexander Klemin, and Ernest Schelling acting in an advisory capacity.

This is another way of saying that while on the one hand the problem reduces itself to that of developing an objective method of measuring loudness, on the other hand any such method must take into consideration the various, often very many, frequencies which go to make up nearly all the sounds heard in daily life.

Physically speaking, the problem reduces itself to finding a way of relating heard loudness to physical energy of some sort, the output of which is regulated by the sound and is susceptible to accurate registration and recording.

RANGE OF VIBRATORY FREQUENCIES TO BE CONSIDERED

At this point certain very important questions arise which have occupied the attention of the Committee during several recent meetings. The first question is what shall be the range of frequencies included, and it is thought that for most practical purposes no component of a sound need now be considered if it has a frequency lower than 25 or higher than 12,000 per second. It has been discovered that relations exist between loudness as heard and the vibrational frequency of the sounding body, to the extent that equal physical intensities whereat two sounds of different frequency are evoked, produce unequal effects upon human observers in terms of heard loudness. This brings up the question of the sensitivity of the auditory apparatus, and it becomes evident, on the results obtained by the work that has been done in this field, that the reliability of any method of physical measurement must depend upon the reliability of the existing data concerning what is called the "threshold of audibility" for sounds of different frequencies. Again, it is equally important that in case the adopted method should involve physical comparison between an artificially induced simple tone of presumably fixed properties and the noise under measurement, the sensitivity of the ear as measured both at the threshold of audibility and at some level above that should be very accurately determined. There are unfortunately some discrepancies among the data which have been brought forth on this point. Assuming the data to be satisfactory, it is of course necessary to design the recording and measuring apparatus in such a way that physical modifications shall be introduced into the registration of the physical energies liberated by the sound and measured by the apparatus. These modifications will of course be predicated upon the principle that the ratio between physical intensity and heard loudness is not the same at all frequencies.

NATURE OF MEASURING APPARATUS NECESSARILY ELECTRICAL

In the known state of the art it is of course evident that the measuring apparatus, hitherto merely described by the term "physical," will necessarily be electrical, and will include some microphonic device for picking up the sounds to be measured, some regulating network to rectify the resulting electrical vibratory energy, and some series of electrical circuits which will modify and in effect analyze the electrical energy by distributing it through the frequency range proposed, in such a manner that the amounts of the energy severally corresponding to the frequencies disclosed will be kept separated. At the same time, however, on account of the known facts concerning the relation between intensity and heard loudness at various frequencies, it will be necessary to introduce artificial modifications of these individual elements.

The registered result of an apparatus like this would correspond of course to the integrated result of the whole measuring operation. A set of electrical networks of the kind suggested would be complex, and it is not yet certain whether any existing apparatus satisfies all the stated conditions. On the other hand, it is also to be remembered that weighting values might have to be introduced for low, medium, or high intensity values, since sounds of given frequencies vary in their heard-loudness values according to their position in the frequency scale. Thus low-frequency sounds in general possess loudness values smaller in proportion to their physical intensity than is the case with sounds of high frequency. It is extremely probable, on all the evidence that has been adduced, that the Committee will be obliged to recommend a compromise, for the purpose of reducing the complexity of the apparatus and making it physically as well as commercially manageable. The question to be decided will be whether a comparatively large number of weighting networks should be designed to weight separately for frequencies and for physical intensity of production; or whether on the other hand we should attempt to combine all that is known of the response of human hearing to different frequencies at different intensities and bring the thing down to two or three frequency-weighting networks, each one holding for a given range of intensities. This would much simplify the matter, but would rest upon data concerning the accuracy of which there is still some doubt.

Remote-Controlled A-C. Haulage Installation at a Portland Cement Plant

Details of Equipment Used in Transporting Limestone From Quarry to Crusher at Plant of the Trinity Portland Cement Co., Dallas, Tex.—Advantages and Disadvantages of Alternating-Current Equipment for This Type of Haulage and Control

By R. F. Emerson,[1] Schenectady, N. Y.

At this plant, cars controlled from a distance transport limestone from quarry to crusher house without train crews. A good conception of the installation may be had from the following tabulation of data.

Material handled	Limestone
Length of track	1 mile (approx.)
Number of cars used	4
Gage of track	Standard
Weight of each car empty	42,000 lb.
Weight of each car loaded with limestone	64,000 lb.
Speed of cars	13 m.p.h.
Weight of running rails	56 lb.
Weight of 2 third rails	40 lb.
Number of main control stations	2
Number of isolated track sections	19
Maximum grade against a loaded car	3 per cent
Maximum grade with empty car	6 per cent
Type of car	Birdsboro
Method of loading car	By electric shovel
Method of dumping car	By electric hoist
Track layout and power-transmission line	See Fig. 1
Power supply, 3 phase, 220 volts, 25 cycles	
Manufacturer of cars	Atlas Car & Mfg. Co.
Manufacturer of electrical equipment	General Electric Co.

A reasonably clear idea of the operation of the cars can be obtained by referring to Fig. 1. The lower part of the diagram represents the insulated track sections, which are numbered up to 20, extending from the crusher (section 2) to the quarry (section 14). The upper part of the diagram shows a 2200-volt transmission line extending along the track which is used to take power to the electric shovel. Ten 100-kva. transformers are installed at intervals between this 2200-volt line and the track for the purpose of transforming the voltage down to the track voltage of 220 volts. The secondaries of the transformers are tied to the 220-volt bus. The midpoint of each track section is energized from this 220-volt bus through reversing contactors contained in weatherproof boxes. Fig. 2, a view from the quarry face, also shows several of the transformers, contactor boxes, and the transmission line. One of the feeder circuits from the 220-volt bus is shown in Fig. 1 connected to the midpoint of track section 10 through reversing contactors. Small control wires (not shown on the diagram) run from each of the twenty reversing contactors to the small reversing switches shown on the operator's control desk, Fig. 3. All movements of the cars are controlled from two of these desks, except for the last three sections near the shovel which are under control of the shovel operator so that he can hold the incoming empties until he is ready for them and send out the loaded cars as fast as he has filled them. It should be understood that each individual track section as shown in Fig. 1 is energized or deenergized by its own controlling switch located on one of two main control desks, one of which is illustrated in Fig. 3. For example, if a car is standing on track section 10 when the operator turns his switch for "out," the car starts for the quarry. If, instead, the switch is turned for "in," the car starts for the crusher house, and if it is in the neutral position when a car passes to this section, power is cut off the motor, the solenoid brakes set by spring action, and the car stops.

With this scheme of remote control, there are no train crews required. As compared with less efficient methods, there is less tendency for production to slow up during the day, because the operator experiences no muscular fatigue in operating the small control switches.

Electrical Equipment on the Cars

Fig. 4 shows a motor equipped with a solenoid brake, geared through a double gear reduction to the car axle. There are two such motors with brakes installed on each car. The operating coil of each brake is connected across two motor terminals. Two of the motor terminals are connected to collector shoes and the third is grounded to the car frame. The operation of this equipment is very simple. If a track section is energized with a car standing thereon, the brakes automatically release and the car starts on full voltage. If the car runs on to a dead section or if one of the reversing contactors is opened while the car is running on that section, then power is cut off the motor and the brakes automatically set and the car coasts to rest. This constitutes all the electrical equipment

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that is mounted on a car. The car carries no switches, contactors, controllers, relays, or resistor grids.

The Control System

In a system of this kind it is perfectly feasible to control all operations from one control desk. Due to the configuration and length of the track, however, it was deemed advisable to install one control desk (Fig. 3) at the crusher, which controls track sections on that end of the track, and another desk in a control booth (see Fig. 2) near the quarry. Red and green lights on these desks indicate which way a car is to go. In order that the shovel operator might hold all incoming empties until he was ready for them and send out full cars as fast as they were filled, an auxiliary control panel controlling the last three track sections in the quarry was installed in the electric shovel.

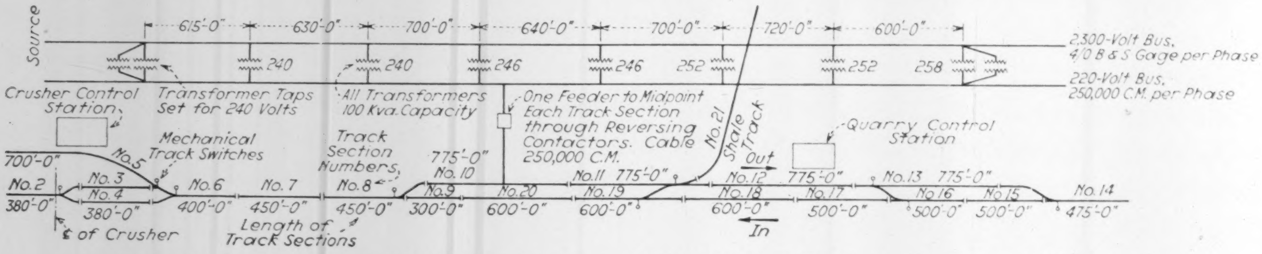
Source
615'-0"
630'-0"
700'-0"
640'-0"
700'-0"
720'-0"
600'-0"
240
240
246
246
252
252
258
2,300-Volt Bus, 4/0 B & S Gage per Phase
220-Volt Bus, 250,000 C.M. per Phase
Crusher Control Station
Transformer Taps Set for 240 Volts
All Transformers 100 Kva. Capacity
One Feeder to Midpoint Each Track Section through Reversing Contactors. Cable 250,000 C.M.
Quarry Control Station
Mechanical Track Switches
Track Section Numbers
No. 21 Shale Track
Out
In
700'-0"
No. 5
No. 2
380'-0"
No. 3
No. 4
380'-0"
No. 6
400'-0"
No. 7
450'-0"
No. 8
450'-0"
775'-0"
No. 10
No. 9
300'-0"
No. 20
600'-0"
No. 11 775'-0"
No. 19
600'-0"
No. 12
No. 18
600'-0"
775'-0"
No. 17
500'-0"
No. 13 775'-0"
No. 16
500'-0"
No. 15
500'-0"
No. 14
475'-0"
℄ of Crusher
Length of Track Sections

Fig. 1 Diagrammatic Sketch of Track Layout and Main Current-Carrying Electrical Connections
(Crusher control station controls track sections 2–9, inclusive; quarry control station, sections 10–21, inclusive.)

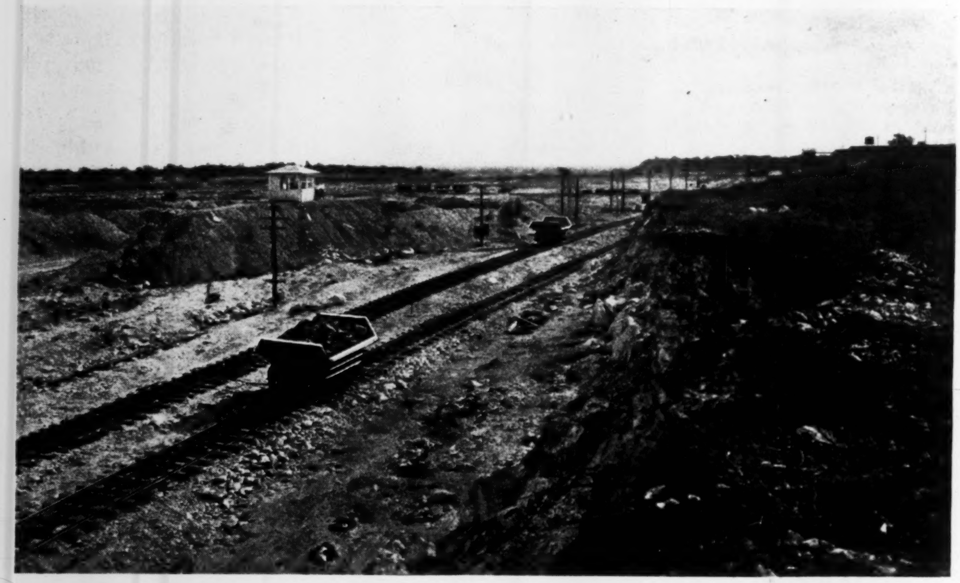

Fig. 2 A-C. Riderless Rock-Car Installation—View From Quarry Face Toward Mill
(Full and empty cars passing in foreground. One of the two dispatchers' stations shown in background. 2300/220-volt distribution. Transformers and control cabinets for full-voltage starting located along track.)

It should be noted that all the control wires leading from these control switches to the reversing contactors carry very small control currents of the nature of an ampere or so. It is not necessary to bring the main power currents for operating the motors up to the control stations. These currents are taken direct to the track system from the transmission line through the transformers and reversing contactors as shown in Fig. 1.

Flexibility of the System

The system is flexible to the extent that more cars can be added to it without increasing the number of operators, and in most cases without increasing the amount of control equipment and the number of transformers.

Additional track sections can be installed, requiring extension to the power lines and one additional control switch on the operator's desk for each track section added.

Maintenance

This system has not been in operation long enough to provide any definite figures on maintenance, but in any electrical installation the control is generally considered the weakest link. Because of the method used in starting the motors, the control for this system is extremely simple, tending to reduce maintenance to a minimum. The only current-carrying devices at the operators' control stations are the little switches on the control desks which carry small control currents of the order of an ampere, so that depreciation due to tip burning is practically nil. The only switches to break heavy operating currents are the magnetic switches enclosed in weatherproof boxes located along the track and shown in Fig. 1, connecting the transformers to the 220-volt bus. Furthermore, most of these contactors open and close on zero current, so that there is no tip burning. The reversing contactors at the two terminals (shovel and crusher) are the ones which do most of the work, because they carry the inrush current when a car starts on a trip to the other end of the track, and are required to break the circuit with current when a car arrives.

The motors used are of the squirrel-cage type, with high-resistance rotors to reduce starting currents and maintain starting torque. This type of motor is very simple in construction, having no commutator, carbon brushes, or slip rings. Consequently it is noted for its ruggedness and "foolproof" characteristics, which also tend to reduce maintenance expense. The transformers used also have low upkeep because of the entire absence of any mechanical wearing parts.

POWER CONSUMPTION

Tests made at the plant over a period of several hours have shown an average power consumption of 0.544 kw-hr. per ton-mile. This does not include power taken by the electric shovel. The power consumption of the shovel during this period was 50 per cent of the power taken to operate the haulage system.

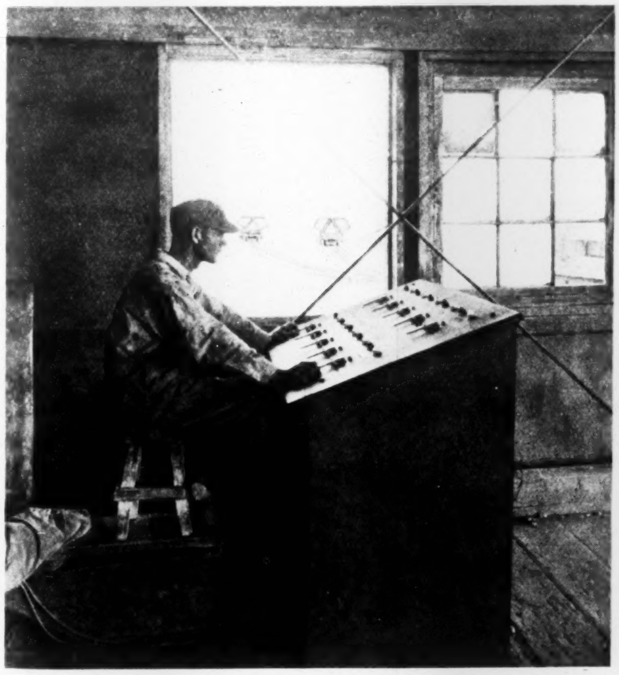

FIG. 3 VIEW OF CONTROL DESK IN CRUSHER HOUSE SHOWING DISPATCHER AT WORK
(One type SY-105 control switch and two indicating lights used for each of 10 sections of track.)

ADVANTAGES OF THE A-C. SYSTEM

Since most haulage systems of this kind, both of the remote-controlled type and those where operators ride on the cars or electric locomotives, have direct-current motors and control, characteristics peculiar to the a-c. system will be discussed as follows.

It is practically impossible for runaways to occur with this type of equipment, even though loaded cars are required to run down very steep grades. If power is on, the motors regenerate and brake the load. If power fails, the brakes automatically set immediately because they are actuated by coil springs, the pressure of which is constantly overcome by the electric solenoid while power is on.

It is an inherent characteristic of the induction motor that it regenerates power and acts as a brake when it is overhauled, as is the case when a car goes down grade. This change from motor torque to braking torque is automatic and inherent in the motors themselves, and does not depend on a human operator or on any electrical or mechanical device such, for example, as a relay or a cam.

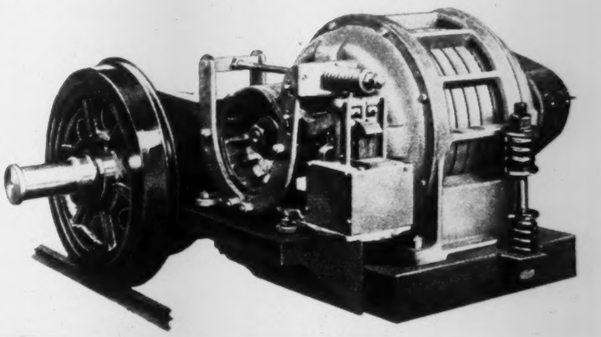

FIG. 4 50-HP., 750-R.P.M., 220-VOLT SQUIRREL-CAGE INDUCTION MOTOR, WITH BRAKE, ASSEMBLED. PART OF TRUCK FOR A-C. REMOTE-CONTROLLED HAULAGE CAR

FIG. 5 CAR LOADED WITH 11 TONS OF ROCK ENTERING CRUSHER HOUSE. DISPATCHER AT WINDOW
(Car equipped with two of the 50-hp. motors shown in Fig. 4.)

Since the cars themselves are operated entirely from the control desks, there is no reason whatever for any one to approach them during the usual routine of operation.

DISADVANTAGES

The present paper would not be a fair exposition of all phases of this type of haulage system unless it directed attention to the following disadvantages which are inherent in the equipment used.

1 As compared with a direct-current system, this three-phase system requires an extra rail and collector shoe.

2 When starting on full voltage, a squirrel-cage induction motor may draw as much as eight times its

normal current, which may result in an excessive drop in voltage if adequate feeder copper is not provided. In the present installation, motors with high-resistance rotors which reduce this high inrush current were used in order to reduce the voltage drop to a minimum. By test, one of these motors will draw 810 amperes at normal voltage.

3 An induction motor suffers a loss in starting torque corresponding to the square of the voltage, hence good rail bonding is essential. In the present installation all four rails were bonded according to accepted electric-track practice.

4 Since the cars are set in motion by starting the motors on full voltage, it is necessary to design motors whose starting torque will not be great enough to spin the wheels of an empty car, and which will yet be powerful enough to propel a loaded car up the steepest grade that will ever be encountered in the quarry. However, it should be noted that with any motor, whether direct-current or alternating-current, it must be possible to limit the torque to a point where it will not spin the wheels of an empty car when starting up.

The fact that the squirrel-cage motor is inherently a constant-speed motor is not listed here as a disadvantage since in quarry operations, as generally encountered, fine speed control is not required. It is true that reduced speed may be required at the crusher and at the shovel in order to spot a car, but the inertia of the car is great enough to hold the speed down while the operator jogs his control switch, and furthermore the instant the control switch is brought to the "off" position, the powerful solenoid brakes go into action and stop the car.

Such experience as has been obtained on the present installation for quarry service indicates that the simplicity and ruggedness of the motors and control, the reduced maintenance, small power consumption, and entire absence of all control devices on the cars themselves, more than offset such disadvantages as may be inherent in the alternating-current system.

Technological Unemployment—A British View

"TECHNOLOGICAL Unemployment" is a term more frequently heard in the United States than in this country. It is one of those loose but convenient expressions which may almost be regarded as scientific slang. It means that kind of unemployment which results from technical progress.

The mere fact that a term of the kind should be in currency is a tacit acknowledgment of the existence of the condition it describes. Years ago no one would have listened patiently to a suggestion that such a thing could happen. It was held, with complete justness, that every technological improvement caused an increase of employment; never a decrease. A temporary displacement of labor might take place, but actual unemployment never resulted. Every new device invented by the technician, every new method introduced by the application of science, led at once and quickly to reduction in price and an increased demand for the products of the industry affected. Hence employment increased. The working people did not see things in that light, but as a matter of actual fact, the inventor was their great benefactor. He increased at one and the same time the number of people employed, the wages they received, and the number of commodities they could enjoy. It would be fruitless to deny that circumstances have changed and that innovations may nowadays have the opposite effects. But it would be a mistake to regard this result as sudden and unexpected. It has been coming upon the world in a beneficent form for years. Every technological improvement has sooner or later led to the reduction of hours of labor, and in that limited sense has caused partial unemployment, or—to put it the other way round—has obviated the necessity for engaging men. The twelve-hour day fell to the nine, the nine to the eight, because improvement of processes accelerated output. How much further will the process go? The main thing that holds up the five-day week is the reduction of the "load factor" of the factory. There is talk already of a three-day week in America. It must come, sooner or later, unless the world will accept one of two alternatives. Either it must give up technological development or it must limit the number of factories.

Here we are on the horns of a very desperate dilemma. If we call a halt to technological progress, if we so order our works that they shall give plenty of employment—that is to say, if we regard the giving of employment as the prime business of factories—we must sacrifice the unquestionable advantages in reduction of price which result from quantity production by accelerated methods. If, on the other hand, we decide not to forfeit the manifest advantages of technological improvements, if we decide to push rationalization to its logical limit—we must inevitably cause "technological unemployment." The capacity for world production of commodities has not nearly reached its limit. The processes of today are several times as rapid as those of the past. But they are still far from asymptotic. The future, if unhindered, will see our present state of production multiplied, and at the same time it will witness the industrialization of many nations which are now agricultural or indefinite. Not the finest selling organization in the universe can prevent the rate of production exceeding the possibility of consumption, and we shall be forced to reduce the hours of labor in order to give employment.—*The Engineer*, Nov. 14, 1930, p. 544.

Maintenance of the Illumination System of an Industrial Plant

Details and Results of an Efficiency and Depreciation Study of Shop Lighting Fixtures Undertaken to Obtain Definite Data Upon Which to Base Recommendations Regarding Lamp Renewals and Cleaning Schedules

By R. C. SMITH,[1] NEW YORK, N. Y.

IN THE average industrial plant the efficient operation of a well-designed illumination system depends primarily upon two variable factors, lamp depreciation and dirt. If the exact rated voltage is applied to all lamps at all times, the decrease in efficiency through filament evaporation is easily determined from the manufacturers' laboratory tests. Also, a rough conclusion as to the approximate amount of dirt on a fixture may be reached at any time from a physical examination. But in the average industrial plant, voltage regulation is not economically feasible to a degree comparable to the regulation adhered to in laboratory tests. Furthermore, though the amount of dirt was actually determined for any one fixture or set of fixtures, no data were available to show the exact effect produced on the efficiency of the fixtures under the particular operating conditions of the company with which the author is connected. In order, therefore, to obtain definite data upon which to base recommendations covering systematic lamp renewals and cleaning schedules, at least within its plants, an efficiency and depreciation study of shop lighting fixtures in the company's Kearny works was made over a period of eleven months—from March, 1928, to January, 1929, inclusive. The immediate objects of the tests were to determine:

- *a* The decrease in illumination intensity caused by varying amounts of dust, dirt, and fumes as found in different classes of manufacturing operations
- *b* The effects of different cleaning methods
- *c* The decrease in illumination intensity caused by natural aging of the lamps, and
- *d* The desirability of relamping fixtures after a specified time, even though the lamps continue to burn.

In considering the results herein set forth it is necessary to bear in mind the fact that no part of the study was in any sense a laboratory test. Therefore irregularities may be noted which were caused by factors controllable in the laboratory but not easily controllable in the shop. No attempt was made at any time to adjust the voltage, since it was felt that the company's voltage regulation was as good as the average within economical limits and since results were desired which would picture conditions as they actually existed, good or bad. This condition accounts, to some extent, for a few apparently inconsistent illuminometer readings.

Illumination in all the locations referred to was furnished by glassteel diffusers properly spaced and mounted to consume 1 watt per sq. ft. with 100-watt lamps, 2 watts per sq. ft. with 200-watt lamps, etc. The ceiling and upper walls were finished in clean, flat white, and the lower walls (5 ft. 6 in. from the floor) in dark green. All readings were taken with a Macbeth illuminometer, the actual values recorded being the average of three readings at each position.

Methods of Procedure

Four locations were chosen on various shop floors where conditions relative to dust, dirt, and fumes were representative of many similar locations throughout the plant. Two particular fixtures in each location were cleaned as thoroughly as possible with a dry cloth and equipped with a new 200-watt lamp together with a red "hands off" tag. The second fixture in each location was kept under test merely as an alternate source of information in case the lamp in the first fixture burned out before the test was completed. The readings from only one lamp enter into the results. The four locations were as follows:

Location *A*—Relatively clean atmosphere (shop office)
Location *B*—Light dust (small-parts assembly)
Location *C*—Heavy dust (cotton braiders)
Location *D*—Fumes (insulating machines).

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For 22 consecutive weeks, representing a total estimated burning time of approximately 1000 hours, weekly illumination-intensity readings were taken directly under each lamp.

At the end of the twenty-second week all fixtures were again dry-cleaned and the intensity noted. One fixture was then cleaned successively with carbona, soap and water, and a solution of trisodium phosphate. The results obtained with the trisodium phosphate were so far superior to those obtained by any of the other methods that the readings taken after the carbona and soap-and-water cleanings were discarded and trisodium phosphate used exclusively as a wet-cleaning agent on all of the remaining fixtures. A test was also made at the end of the twenty-second week to determine the extent of lamp aging. A slight difference between the old and a new lamp could be noted on the illuminometer, but the difference was not sufficiently great to warrant the replacing of the lamp, or even to effect the performance curve to a noticeable extent. Consequently the old lamps were again installed in each of the test fixtures.

Following the above cleanings, the identical procedure was repeated for a second period of 22 weeks, at the end of which the test was concluded and all results plotted into curve form as shown in Figs. 1 and 2.

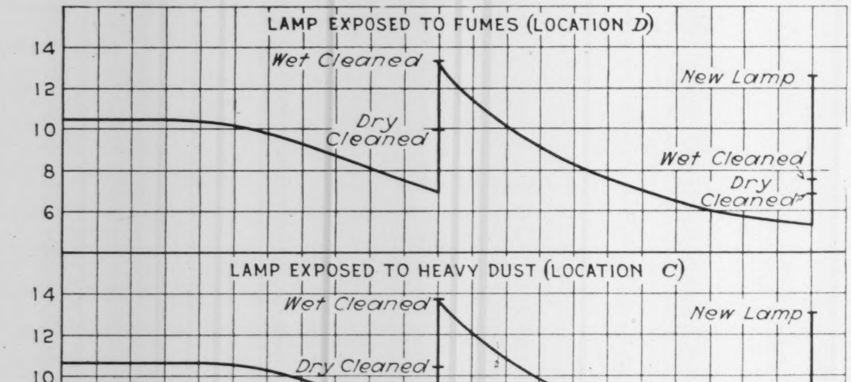

Fig. 1 Curves Showing Depreciation of Lamps Due to Dirt and to Aging, and the Effects of Cleaning and of Lamp Renewal

(200-watt lamps in glassteel diffusers. Estimated number of burning hours per week, 45. "Wet cleaned" refers to use of trisodium phosphate dissolved in warm water.)

Discussion of Lamp-Depreciation Curves

The curves in Fig. 1 show the [illegible]al trend of fixture efficiency, [illegible] results of cleaning, and the fact [illegible] the two halves of each curve, corresponding to the two halves of the test, are of decidedly different shapes. This latter condition is undoubtedly due to lamp aging, which begins to show effect about the twenty-eighth week, and which accounts for the extremely low intensities recorded near the end of the tests.

For the first half of the test period it will be noted that each intensity curve begins to drop after a length of time depending on the amount of atmospheric dust to which the fixture was exposed. For example, the fixture in the relatively clean atmosphere (location *A*) gives a fairly constant intensity for 16 weeks, while the lamp exposed to fumes (location *D*) shows a decided decrease in intensity after the eighth week.

The effect of dry cleaning follows roughly the same rule: i.e., dry cleaning is relatively ineffective with heavy dust and fumes but fairly satisfactory with little or light dust. The wet-cleaning method (trisodium phosphate solution) accomplishes approximately the same results regardless of the character of dirt which has accumulated on the fixture, and in general represents a striking advantage over dry cleaning. This is especially evident from the fact that the intensity values after wet cleaning were far in excess of the original starting values.

Involved in the second half of the test is a new element which brings about a considerable difference in the shape of the curves. From the time of the first wet cleaning it will be noted that all curves drop very sharply. However, within the first few subsequent weeks each curve might well have been expected to straighten out approximately on the line of 10 foot-candles, as in the previous half of the test, had not the element of lamp depreciation entered into the results. That this element was definitely present is unquestionable after a consideration of the final readings. Thus, to curves already showing the effects of dust was added the extra detrimental effect of lamp aging, with the net result that the drop not only continued but was accelerated to a point appreciably below the figure reached at the conclusion of the first half of the test. At this low point neither wet nor dry cleaning resulted in any marked improvement. The installation of a new lamp, however, brought all intensities up approximately to the previous wet-cleaned value.

From these curves an imm[illegible] answer may be had to the two main questions, i.e.,

a How often should fixtu[illegible] be cleaned?

b Should old lamps be renewed before they actually burn out?

Concerning question (*a*), in the particular lighting system under consideration the average 200-watt lamp, reasonably new and reasonably clean, gives an intensity immediately beneath it of about 12 foot-candles. The intensity at the center of a square bounded by four regularly spaced 200-watt lamps is about 10 foot-candles, so that a good general average may be taken as approximately 11 foot-candles. This figure does not represent maximum possible efficiency, but it is believed that it represents the highest efficiency which it is economically practicable to obtain, and an efficiency slightly higher than successful operation demands. Let us assume, then, that the 11 foot-candles represents arbitrarily 100 per cent efficiency and that on such a basis we are willing to allow the system to operate at an efficiency of not less than 90 per cent. We now see that lamp *D* operated at an efficiency of 96 per cent for 8 weeks after cleaning and dropped to 88 per cent at 12 weeks. Similarly lamp *C* operated at 97 per cent efficiency for 9 weeks and dropped to 83 per cent at 14 weeks; lamp *B* operated at 93 per cent for 12 weeks and dropped to 88 per cent at 14 weeks; while lamp *A* operated at 93 per cent for 14 weeks and dropped to 89 per cent at 16 weeks.

From these figures we conclude that:

a Lamps exposed to heavy fumes, such as lamp *D*, should be cleaned every two months

b Lamps exposed to heavy dust, such as lamp *C*, should also be cleaned every two months

c Lamps exposed to light dust, such as lamp *B*, should be cleaned every three months; while

d Lamps exposed to very little dust, such as lamp *A*, render satisfactory service if cleaned only once every four months, and that in none of these cases is there a marked advantage to be gained by cleaning oftener.

Based on these conclusions, definite cleaning schedules have been set up in accordance with actual manufacturing conditions for the whole Kearny plant. From experience with cleaning methods there it can also be said that all cleanings should be of the wet type, using a solution of trisodium phosphate or its equivalent.

Next comes the question of lamp renewals. The appreciable increase in intensity resulting from the installation of new lamps indicates a decided economic advantage to be gained by a systematic program for renewing lamps over the entire plant before they are actually burned out, especially since the plant's average is somewhat low and lamp life consequently abnormal. Obviously, however, such a program would involve the keeping of expensive clerical records, the cost of which would undoubtedly offset the value of any resulting gain in illumination efficiency. Furthermore, such records, if kept, would necessarily be highly hypothetical, since no ready means exists of determining the exact number of hours that any particular lamp has burned.

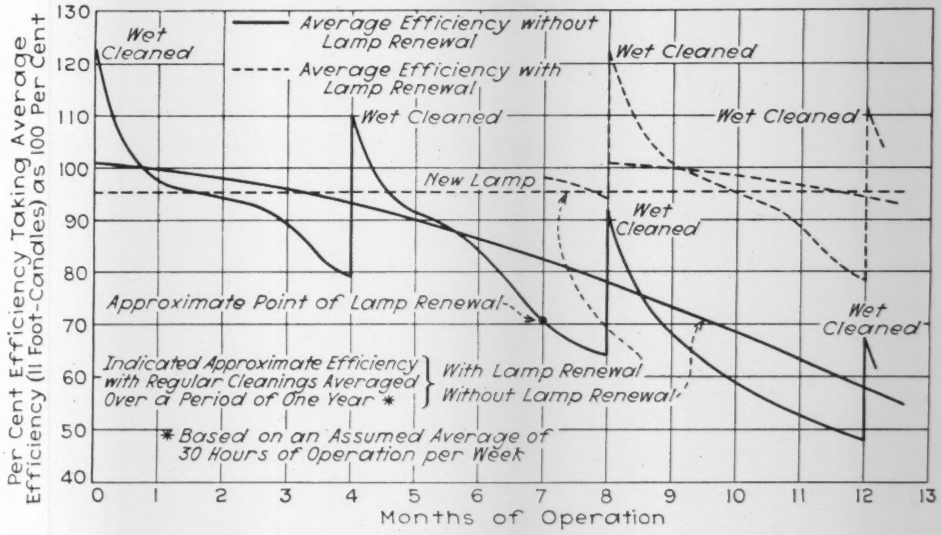

FIG. 2 AVERAGE LAMP AND FIXTURE EFFICIENCY CURVES SHOWING ADVANTAGE GAINED BY LAMP RENEWALS

In an effort to prevent the extremely low operating efficiency of very old lamps and at the same time to avoid the expense of keeping costly clerical records, a plan is being considered whereby all four lamps on any column or wall switch are to be renewed when any one burns out. By systematically following such a procedure a condition is eventually set up wherein all the lamps on any one switch in the plant are of exactly the same operating age at all times, and when one burns out the others may reasonably be presumed to have passed their period of acceptable efficiency. Naturally, some lamps burn out prematurely, and when such a case occurs three other lamps are automatically thrown away, even though they still retain a portion of their economic usefulness. Also the expense for material is obviously greater than when one lamp is renewed at a time, though the expense for labor does not logically increase in the same proportion. The only hope of offsetting these disadvantages lies in increased production or decreased rejection brought about through increasing lighting efficiency.

The basic idea seemed sufficiently attractive to warrant further investigation. Accordingly about April 1, 1930, a room similar to any of those shown in Figs. 3–6 was divided longitudinally into two halves by an imaginary line down the center of the main aisle. Orders were issued that when a lamp burned out in one half of the room only that one lamp should be renewed, while in the other half when any one lamp burned out all four lamps on that particular switch were to be renewed at the same time. During the entire investigation accurate illumination efficiency and cost records, including both labor and material, were to be kept independently for each half of the room and compared at the end of definite periods.

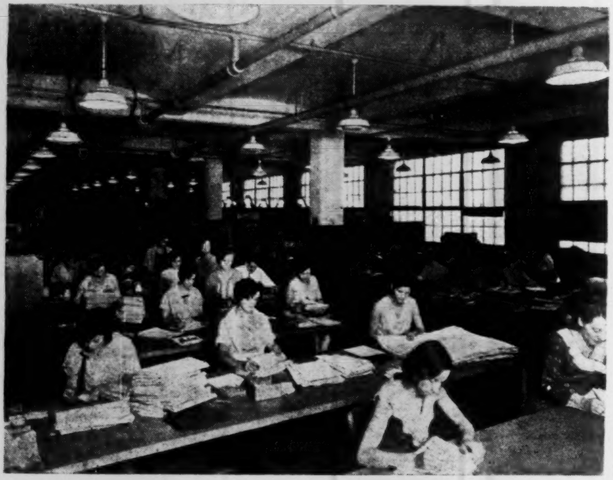

FIG. 3 LOCATION "A"—CLEAN ATMOSPHERE

At the present time the test has not been completed, and therefore the data obtained have not been thoroughly analyzed. Over a period of about ten months, however, the total cumulative expense for labor, material, and loading has been found to be about $4^1/_2$ cents greater per fixture on the four-lamp side than on the one-lamp side of the room. The extra expense for lamps alone is about 7 cents per fixture, but an actual saving of $2^1/_2$ cents per fixture in labor has been made on the four-lamp side. Contrary to the expectations, however, the illumination intensities on the two sides of the room have remained approximately equal. But less than half the total number of lamps on either side of the room have been renewed even after ten months of operation, and therefore an authentic indication of the ultimate gain in efficiency can hardly be expected.

While the eventual outcome of this test and the cost figures obtained are looked forward to with extreme interest, it is still felt that probably the most universally satisfactory method of preventing the extreme inefficiency of old lamps is to keep the circuit voltage as close as possible to the rated voltage of the lamp. The more closely the two voltages agree, the greater is the likelihood that the majority of the lamps will burn out at or near their rated 1000 hours, and thus the extremely old lamps will automatically eliminate themselves. The chief reason for unusual interest in the results of the four-lamp renewal test lies in the previously mentioned fact that close voltage regulation in the average industrial shop is a far more difficult matter than the same degree of regulation in the laboratory where life tests are generally run.

Fig. 2 shows graphically the extremely low efficiency resulting from the use of old lamps compared to the yearly average efficiency attained when systematic renewals are made. The efficiency values from which the curves are plotted are based on a composite of the four curves shown in Fig. 1.

SUMMARY OF RESULTS

For the sake of ready comparisons, percentage figures covering the complete test are tabulated at the top of page 375. All figures are based on the assumed 100 per cent efficiency corresponding to 11 foot-candles intensity.

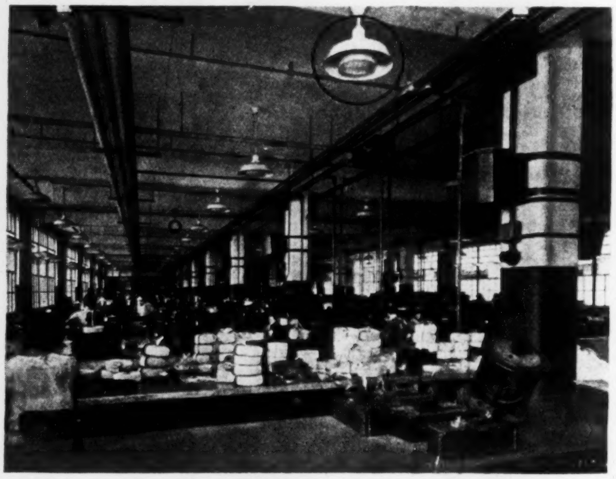

FIG. 4 LOCATION "B"—LIGHT DUST

An interesting fact brought out by these figures is that all fixtures, whether exposed to light or heavy dust, will eventually reach approximately the same state of inefficiency, and will therefore be equally benefited by cleaning.

At the conclusion of the test, an effort was made to determine the cause of the marked downward trend of the curves immediately after wet cleaning. A representative glassteel reflector was cleaned in small adjacent areas with a dry cloth and with trisodium phosphate, and the two areas subjected to microscopic scrutiny. The dry-cleaned area showed many minute

	Location A	Location B	Location C	Location D
Average intensity (foot-candles) taken as	11	11	11	11
First Half of Test (New lamp fixture dry cleaned)				
Percentage of average intensity:				
At start of test	93	93	97	96
After 8 weeks	93	93	97	96
After 12 weeks	93	93	93	88
After 16 weeks	89	80	86	79
After 22 weeks	73	56	69	63
After dry cleaning at end of 22 weeks	114	100	95	88
After wet cleaning at end of 22 weeks	127	112	125	121
Second Half of Test (New lamp removed, old lamp put back, fixture wet cleaned)				
Percentage of average intensity:				
After 26 weeks	98	87	100	93
After 30 weeks	78	71	73	75
After 34 weeks	66	60	68	64
After 38 weeks	56	51	55	54
After 44 weeks	48	45	50	48
After dry cleaning at end of 44 weeks	62	64	62	61
After wet cleaning at end of 44 weeks	73	73	71	68
After wet cleaning and removal of lamps at end of 44 weeks	116	107	116	116

pores from which the dirt had not been removed, while the wet-cleaned area presented practically the same surface as a new reflector. This fact leads to the theory that even when dry cleaning is thoroughly done, all the dirt is not removed from the pores of the reflector. These pores are efficiently cleaned by the wet method, but rapidly fill up when the reflector is again placed in service.

Considering lamps in all four locations, it will be noted that during the first month after wet cleaning the highest intensity obtained was 127 per cent of the arbitrarily chosen 11 foot-candles, while the lowest was 86 per cent. The general overall average for the month was well over 100 per cent. Therefore the question may logically be asked: Why not wet clean all fixtures every month, and thus obtain the benefit of extremely high efficiencies during the first week or so, and excellent average efficiencies during the entire month? The answer, in the author's opinion, is that the extremely high intensities are too short-lived to warrant the expense of such frequent cleanings. Any lighting intensity is valuable mainly in so far as it is reflected in production efficiencies. The high intensities entail from two to four times the cleaning expenses of the so-called normal intensities, and these expenditures are not believed to be justified by production records.

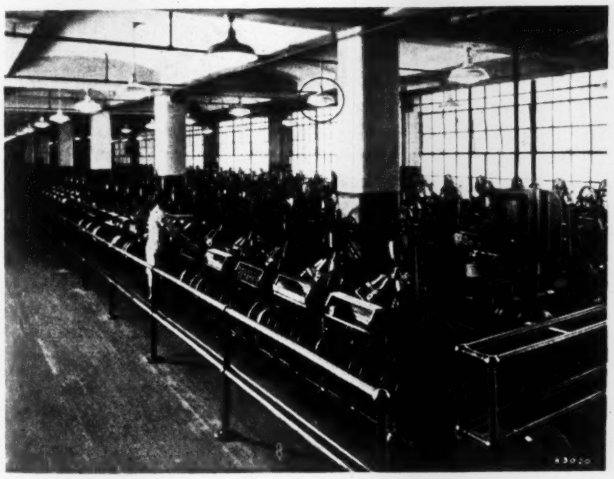

Fig. 5 Location "C"—Heavy Dust

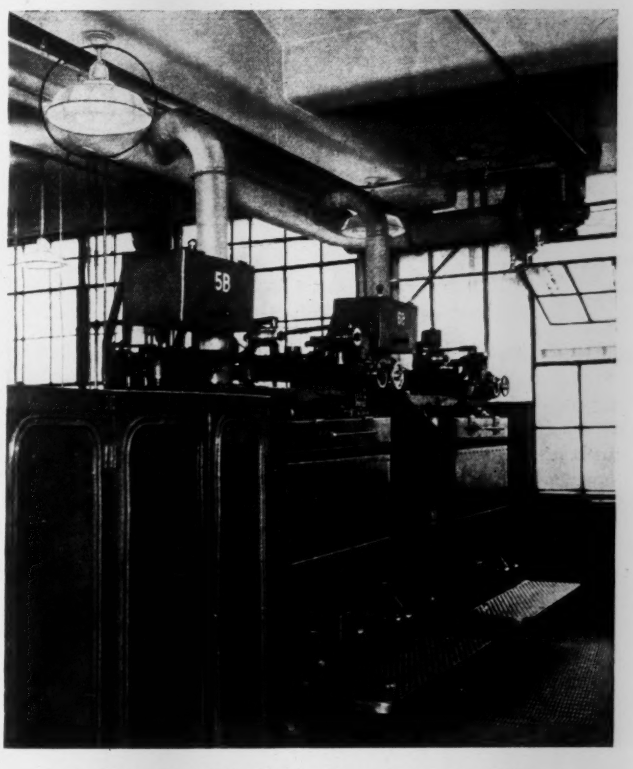

Fig. 6 Location "D"—Fumes From Insulating Machine

The Tercentenary of Henry Briggs

SEVENTEEN years ago we dealt at length with the celebration, in Edinburgh, of the tercentenary of the publication by Napier of the small quarto volume, "Mirifici Logarithmorum Canonis Descriptio," which contained the first account of Napier's great discovery of logarithms, a discovery which, as Lord Moulton said, came upon the world as a bolt from the blue. That the new method of computation almost immediately became known throughout Western Europe was not, however, due to this book of Napier so much as to Henry Briggs, through whose exertions the first tables of logarithms to the base 10 were formed. Within a few years of Napier's death, in 1617, German, French, and Italian mathematicians and astronomers were using logarithms in their calculations, and this was mainly due to the activities of Briggs. A man of immense industry, Briggs continued to devote himself to the compilation of logarithmic tables all through his later years, and his third work, containing tables of sines, tangents, etc., was only partly completed when he died. His death took place on January 26, 1631, at Oxford, where he was Savilian professor of geometry. —*Engineering*, Feb. 6, 1931, p. 171.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Airscrews for High-Speed Airplanes

SINCE little is known of the characteristics of an airscrew at the high rates of advance which occur with modern racing airplanes, it is desirable to examine theoretically the most suitable type of airscrew for modern and future high-speed airplanes, to determine the efficiency of these airscrews, and to consider the possibility of improving the low static thrust which usually accompanies a high pitch-diameter ratio.

Adopting a few simplifying assumptions, the characteristics of a series of high-pitch airscrews have been calculated, and these results have been used to establish a relationship between the pitch-diameter ratio, torque coefficient, and solidity of an airscrew operating near the state of maximum efficiency. Another approximate formula has been derived for the efficiency of the airscrew, and these formulas have been used to determine the most suitable type of airscrew for a high-speed airplane. A simple formula has also been derived for the static thrust of a high-pitch airscrew.

The analysis suggests that the tip speed of the airscrew may be limited to the moderate value of 900 ft. per sec., and, using a suitable gear ratio, an efficiency of over 80 per cent may then be anticipated. For a modern racing airplane, the most suitable airscrew is one with two blades of 10 ft. diameter and it is necessary to use a gear ratio of the order of 0.6, but as the speed of the airplane increases the need of a gear ratio will disappear and the most suitable airscrew will be one of smaller diameter with a larger number of blades. The relatively poor static thrust is an inevitable consequence of the high speed of the airplane, being directly proportional to the power of the engine and inversely proportional to the speed of the airplane, irrespective of the diameter of the airscrew or of the gear ratio; the only hope of improvement is to use a variable-pitch airscrew. (H. Glauert in a mimeographed communication by the Director of Scientific Research, Air Ministry, from *Reports and Memoranda No. 1342* (*Ae. 474*), June, 1930, original 18 pp. and 7 diagrams, *e*)

Validity of Large-Scale Tests in an Open-Jet Wind Tunnel

THE tests discussed by the author were undertaken to investigage the possibilities of experiments in an open-jet tunnel upon airplanes of wing span greater than the jet diameter. Interest in the tests was chiefly concerned with the measurement of changes in the force along wind, due to changes in the parts of the airplane situated near the center of the jet.

The tests were carried out in a 5-ft. open-jet tunnel on a one-fifth-scale model Bristol Fighter. Lift and drag without airscrew, and with stopped airscrew, and the lift and net thrust with airscrew running have been measured at angles of incidence varying from —4 deg. to 8 deg. From the results the pitching moments have been calculated, the additional drag due to a stopped airscrew has been deduced, and the effective thrust of the airscrew has been determined. The results are compared with those for similar tests carried out on the same model in the Duplex tunnel at the National Physical Laboratory, Teddington.

In addition, some exploration of the jet was made with the model in position.

The tests have demonstrated the possibility of measuring in an open-jet wind tunnel the changes of drag or thrust resulting from modifications to parts of the airplane situated near the axis of the jet, even when the airplane span greatly exceeds the jet diameter. (W. G. A. Perring and C. Callen, in a mimeographed communication by the Director of Scientific Research, Air Ministry, from *Reports and Memoranda No. 1348* (*Ae. 480*), July, 1930, original 12 pp. and 9 diagrams, *e*)

HYDRAULIC ENGINEERING

Tidal Energy

THE author describes three methods of converting the intermittent supply of tidal energy into a continuous one. The two most interesting are one proposed by Shishkoff and another by a Swiss engineer, Huguenin. In the Shishkoff scheme a heat accumulator is adapted to the special case of conserving power obtained from tidal or other hydraulic sources.

These accumulators will store steam produced by an ingenious modification of a hydraulic brake inserted on the main driving shaft between the water turbine and the alternator. The steam thus stored will be available to drive a steam turbine direct coupled or geared to another alternator, thereby providing electrical energy during the "dead" periods when the difference in water levels is insufficient to secure direct power from the tides. The promoters of this scheme, however, realize the efficiency of their project may be low, and therefore contemplate the addition of an ordinary steam plant to supplement the accumulators. The scheme proposed for the Severn estuary is also said to use only one-way flow turbines; as a result the demand on the ordinary steam plant and the accumulators will be heavy, and as the latter give a low return in power for the energy put into them, the total loss on the tidal system must be great and the continuous electrical power supply possibly may not exceed 25 per cent to 30 per cent of the power developed by the water turbine.

In the Huguenin scheme a part of the power of each tidal movement will be used to compress air into suitable containers. The air so compressed can be released again as desired, to drive the plant when the main power from the tides is no longer available at the "dead points." The efficiency of the storage plant alone is said to be in the neighborhood of 55 per cent, and owing to patented double-flow turbines being used, power is obtained both from the incoming and outgoing tides, consequently it is only necessary to store a relatively small amount of power to cover the "dead" periods. The double-flow turbines of the type proposed have the further advantage of permitting the turbine casings to be used as sluices completely open or completely shut as may be required.

The complete system is estimated to have an overall efficiency of approximately 80 per cent; that is to say, over 80 per cent of the power produced by the water turbine can be transformed into electrical energy.

It is understood that a scheme for the Severn, based on this compressed-air T.E.L. (Tidal Energy, Ltd.) system, will shortly be submitted to the government for its consideration and for the purpose of securing the necessary permission to erect the requisite plant.

The proposed dam, with it sluices, locks, and turbines complete, would so cross the Severn that it would be possible to utilize the dam as the basis of both a road and railway bridge over the estuary.

The scheme is also so devised that it can be carried out in two or more stages, the difference between them being the number of turbines and generators, etc., which may be installed. From the first and smallest scheme now proposed for construction there would be available for supply to the main grid system of the country a constant diurnal load of nearly 80,000 kw. or about 1,900,000 kw-hr. per day. In addition to the steady load from this first stage there would be available for sale a further fluctuating load, a considerable part of which at least could be used in the general grid system. The output of the last or completion stage as a steady load would be 280,000 kw. Including the fluctuating load, the total energy available in any year would be approximately 3,500,000,000 kw-hr.

The scheme is said to have the advantage that each of the patents, whose combination is to produce the results indicated, has been utilized separately already for other purposes; thus the value of each of them is well known. The promoters are so confident of the correctness of their views that they have decided to erect a preliminary station at their own expense simply for demonstration purposes, where the value of the whole or each part of their system can be thoroughly examined by those interested. Engineers and others will be given the fullest opportunity to watch and test the results. (*The Engineer*, vol. 151, no. 3919, Feb. 20, 1931, pp. 211–212, *g*)

INTERNAL-COMBUSTION ENGINEERING

Scavenging and Output of Two-Stroke-Cycle Engines

IN FOUR-STROKE-CYCLE engines the connection between output on one hand, and on the other hand size of engine, number of revolutions, and stroke ratio, is fairly clear. There is a lack of precision only in reference to the efficiency when it comes to the limits of smallness of size and of speed. In the case of the two-stroke-cycle engine the situation is entirely different. In addition to the above-named factors, several others come into play, namely, scavenging-air pressure, consumption of air, efficiency of scavenging, and energy consumption of the pump. All of these factors have a great influence on the output, and together they are so difficult to comprehend that in many instances engineers are satisfied with mere estimates. What the author attempts to do is to introduce a certain amount of precision into this field which, notwithstanding numerous reservations, will outline the most important interrelations of these factors. This can be done only when the investigation is limited to a clearly defined and rather narrow range, and to accomplish it the author excludes entirely all questions dealing with combustion and heat stresses, and considers only the influence of scavenging, and then only exclusively pure port scavenging.

Air Consumption. The scavenging pressure p_s gives the air velocity w at the entrance to the inlet port; the time I required for passing the inlet port gives the volume of scavenging air in one stroke V_e, and the comparison with the stroke volume V_h gives the air consumption L. The velocity w at the entrance to the inlet port is given by the law of efflux in the subcritical range of pressure:

$$w = \mu \sqrt{2g \frac{k}{k-1} RT_s \left[1 - \left(\frac{p_a}{p_s} \right)^{\frac{k-1}{k}} \right]}$$

where μ is the coefficient of contraction of the inlet port; R the gas constant for air in m-kg. per kg. per deg. cent., p_a the pressure of the scavenging air in atmospheres back of the inlet port, and p_s its pressure ahead of the inlet port. If μ is taken equal to 0.8, $k = 1.4$, and T_s (temperature of the scavenging air) = 313 deg. cent. abs., while the loss of pressure in the scavenging ports is 65 per cent of the available head for average port conditions, and hence $p_a = 1 + 0.35\ (p_s - 1)$, then

$$w = 638 \sqrt{1 - \left(\frac{0.65}{p_s} + 0.35 \right)^{0.286}} \ \ldots\ldots\ldots\ [1]$$

This is shown graphically in Fig. 1.

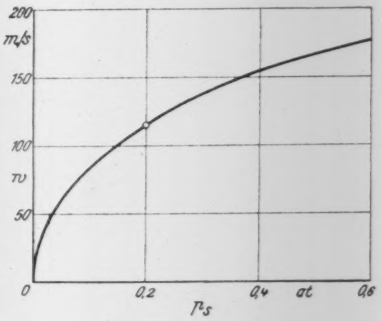

FIG. 1 SCAVENGING-AIR PRESSURE p_s AND AIR VELOCITY w AT ENTRANCE TO INLET PORT

With constant scavenging-air pressure the volume of air entering the scavenging port per stroke is equal to $V_e = w\int f dt$. The time cross-section $Z = \int f dt$ (square-meter-seconds), and can be conveniently replaced by an integral referred to the crankshaft angle and hence independent of the number of revolutions, namely, $I = \int f d\varphi$ (sq. m. × deg.), where $\varphi = 6nt$ (n = r.p.m., t = port opening, sec.); hence $I = 6nZ$. The best way to obtain I is by planimetering. In doing this only the projection at right angles to the direction of flow should be taken for f [area of inlet port (in sq. m.) uncovered by piston]. This gives

$$V_e = \frac{wI}{6n} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ [2]$$

V_e gives the normal volume of scavenging air V_0 by computation on the basis of 15 deg. and 1 atmos. abs., while the ratio of V_0 to V_h (volume per stroke) gives the air consumption L, which is a unit of measurement of the amount of scavenging air independent of the size of the engine. For a given value of V_e the state of the air at the mouth of the scavenging port in the case of subcritical pressure distribution is defined by the specific weight of scavenging air in kg. per cu. m., namely,

$$\gamma_e = \gamma_s \left(\frac{p_a}{p_s} \right)^{\frac{1}{k}}$$

where p_s = pressure ahead of the inlet port = 1.2 atmos. abs., T_s = temperature of scavenging air ahead of the inlet port = 313 deg. cent. abs., and for these values $\gamma_{e\,\text{avg.}}$ = 1.20 kg. per cu. m., and γ_0 = specific weight of scavenging air in its normal state = 1.185 kg. per cu. m.; hence

$$\left. \begin{aligned} V_0 &= V_e \frac{\gamma_e}{\gamma_0} = 0.168 \frac{wI}{n} \\ L &= 0.168 w \frac{I}{nV_h} \end{aligned} \right\} \ \ldots\ldots\ldots\ldots\ [3]$$

Equations [1] and [2] permit plotting the L-curves for any definite values of V_h, I, and n, as has been done in the original article for a motor of certain dimensions. Thus far, however, the author has been dealing with simple applications of the law of efflux of gases.

Scavenging Efficiency. The author now proceeds to the investigation of the efficiency of scavenging η_s which is determined from the amount of air L used in scavenging. This efficiency of scavenging is expressed in volume units of the scavenging air retained in the cylinder at the end of the scavenging period. The determination of η_s has to be made in the first place by the test engineer.

The author considers, however, three cases, of which the first and third are of theoretical interest only. In the first case the total "scavenging" air remains in the cylinder until the latter contains nothing but pure air. In the third case the entire air escapes, so that the efficiency of scavenging is zero. The second case, which is the only one of practical interest, represents a condition where the scavenging air mixes at each instant completely with the contents of the cylinder. At any instant during the process of scavenging (assuming air consumption L and air content η_s) any further introduction of air changes L by the amount dL, and a similar volume with the air content η_s escapes through the exhaust port as shown in Fig. 2.

The amount of pure air escaping is therefore $\eta_s dL$, while the amount that remains is $dL - \eta_s dL$, where L is expressed as a fraction of the stroke volume. As a fraction of the total volume, the amount of air that remains would be expressed by $\zeta(dL - \eta_s dL)$. The increase in air content is therefore

$$d\eta_s = \zeta(1 - \eta_s)dL$$

$$\int \frac{d\eta_s}{1 - \eta_s} = \zeta \int dL$$

$$-\log_e(1 - \eta_s) = \zeta L + C$$

For $L = 0$, $\eta_s = 0$, and hence $C = 0$,

$$\eta_s = 1 - e^{-\zeta L} \qquad [4]$$

Fig. 3 shows the course of variation of η_s in cases 1, 2, and 3 referred to above. The region between the curves a and b shows desirable stratification of the scavenging air, and the region between b and c undesirable stratification. Curve b indicates a purely diluting form of scavenging. In actual practice both stratification and escaping of air are present, and it needs only a very small amount of escaping in order to depress markedly the curve for η_s. It is well to remember that Equation [4] is only roughly approximate, because it does not take into account such important matters as pressure, temperature, energy of flow, heat exchange with the cylinder wall, and the variation of the cylinder volume. Neumann (Forschungsarbeiten des Vereines deutscher Ingenieure, No. 334, Berlin, 1930) has derived a curve for η_s for the same case as Equation [4] in the present article, assuming complete intermixing of the scavenging air and gases in the cylinder and taking into consideration the matter of temperatures. This curve of his applies to the case of good scavenging of the Junkers type, that is, with the inlet and exhaust valves at opposite ends of the cylinder.

The author, on the other hand, attempts to find a curve which will come as nearly as possible to average conditions, i.e., scavenging with the scavenging process of medium effectiveness. In his model tests in which a cylinder filled with carbon dioxide was scavenged with air, the curve of η_s obtained by measurements under fairly good conditions of scavenging lay practically always below curve b in Fig. 3, while the Neumann curve lay somewhat above this curve, which would indicate that curve b corresponds to medium conditions, where the improvement due to temperature and the decrease in efficiency due to escape of air seem to be equalized.

Performance. From this the author proceeds to consider the indicated output and the useful output of an engine, and then to a generalization of the equations which he previously obtained. This part cannot be abstracted because of lack of space. Among other things, however, he shows that curve b in Fig. 3 is not generally applicable, and in the tests with various processes of scavenging quite different values for η_s have been obtained, which means that according to the arrangement of the inlet and exhaust ports there were found to exist considerable differences in the effectiveness of the scavenging, which in turn shows that the process of scavenging has a very great influence on the results obtained. Even, however, with the same process of scavenging, its effectiveness may vary considerably with different sizes of the cylinders. This is due to the fact that in order to obtain the same conditions of flow it is necessary to have not only geometric similarity but the same Reynolds coefficient wl/v, where v is the viscosity, and for the same value of v the product wl (where w in meters per second is the velocity of the air at the edge of the inlet port) need not be constant with different values of l. Several other factors also affect the location of this curve. (Dr. of Engrg. Carl Wintterlin in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 75, no. 6, Feb. 7, 1931, pp. 165–169, 15 figs., *t*)

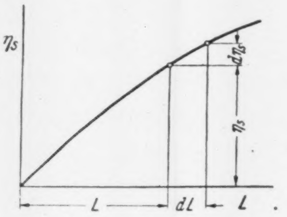

FIG. 2 CURVES SHOWING RELATION BETWEEN THE AMOUNT OF AIR USED (L) AND THE EFFICIENCY OF SCAVENGING (η_s)

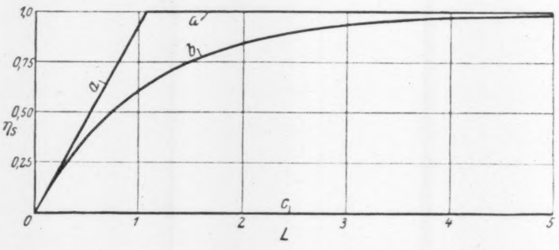

FIG. 3 RELATION BETWEEN THE AMOUNT OF AIR USED (L) AND THE EFFICIENCY OF SCAVENGING (η_s) FOR THREE CASES

(a) $\eta_s = \zeta L$, which means that all the scavenging air remains in the cylinder.

(b) $\eta_s = 1 - e^{-\zeta L}$

(c) $\eta_s = 0$

The Benes Fuel Pump for Oil Engines

IN THIS pump the camshaft is located in the base; and as it has symmetrical cams it can be driven from either end clockwise or anti-clockwise—a great advantage to the engine designer. Each cam operates a pump plunger through a tappet working in large guide; this obviates side thrust upon the plunger and makes for long life and accuracy of metering. The tappet and plunger are returned by means of a coil spring (Fig. 4).

Fuel is forced into the engine cylinder by the rising pump plunger; partial rotation of the plunger, acting in conjunction with a fixed, ported sleeve in which it works, regulates the quantity of oil delivered per stroke, and therefore it controls the speed of the engine in the usual way.

Fixed in the casing is the outer sleeve; at the top of its working space is the vertical delivery port with a simple non-return delivery valve. It is possible to use this form of valve owing to the absence of any tendency to dribbling action of the pump. Drilled horizontally are the suction and relief ports, both in communication with the annular suction chamber in the casing.

Fixed in the outer sleeve is the ported sleeve, the two ports being shaped with one vertical edge and one inclined edge in each case. The third sleeve is for control purposes. It can be rotated, by means of a rack, around the outer sleeve; by reason of vertical slots mating with lugs on the plunger it can impart a partial turn to the plunger while the latter is rising or falling.

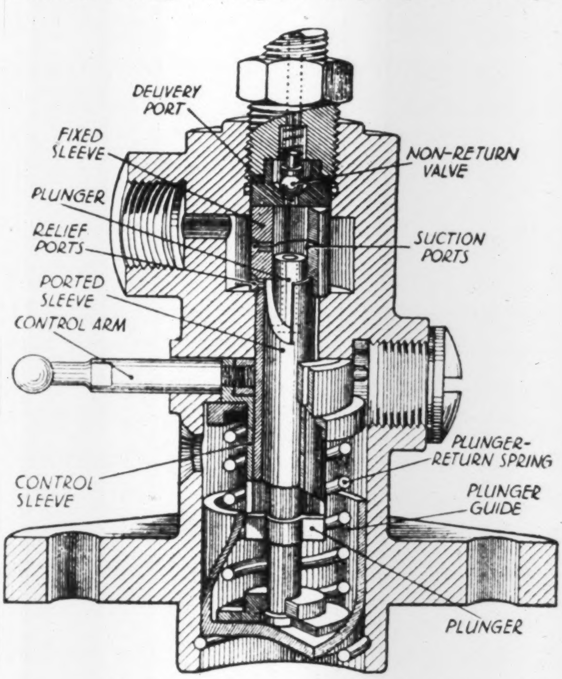

FIG. 4 PARTLY SECTIONED VIEW OF THE BENES PUMP

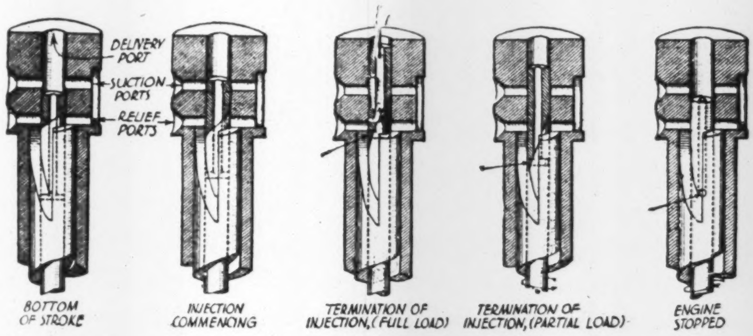

FIG. 5 FIVE DIAGRAMS SHOWING WORKING OF THE BENES PUMP ON FULL LOAD, PARTIAL LOAD, AND WITH THE ENGINE STOPPED

(In the first case pressure is destroyed by registration of the ports in the plunger and the relief ports, while in the second and third cases the ported sleeve serves as the outlet for surplus fuel oil.)

In addition to the rack gear for engine-speed control, each sleeve can be synchronized or tuned; this fine adjustment can be carried out, if necessary, while the engine is running. Comparative settings can be obtained immediately and recorded, and previous settings restored by use of the separate tool and calibrated disk.

At the top of the plunger is a vertical hole communicating with one drilled through the diameter, about one-third of the length from the top.

Turning now to the action of the pump, this matter will be greatly simplified by reference to the series of illustrations (Fig. 5) showing diagrammatically the suction and injection cycle. When the plunger is at the bottom of the stroke the space above it is full of fuel. As the plunger rises, so does the oil. Immediately the plunger seals the suction ports the fuel is forced through the non-return delivery valve above, to the fuel nozzle.

Injection continues until the radial ports of the plunger establish connection with the relief ports in the ported sleeve. Pressure is then instantaneously destroyed as the fuel is bypassed directly into the suction chamber. This obtains when the pump is set for the full-stroke position. If it be required to deliver a smaller quantity than the maximum, the plunger is rotated slightly by means of the rack gear and control sleeve. This causes the radial plunger ports to be uncovered by the inclined edges of the ported sleeve before the completion of the stroke. According to the earliness or lateness of the destruction of pressure, so is the volume of fuel delivered per stroke.

Both the plunger relief ports and the ports in the sleeve communicate directly with the suction chamber, therefore oil not required on any stroke is returned to the suction chamber without waste, while the least possible resistance is thereby offered to the flow of the bypassed fuel.

When the plunger is turned so that its relief ports coincide with the bases of the openings in the ported sleeve, no fuel can be delivered and the engine stops.

A study of the design and working principles shows that the ends of the injection period are definite, i.e., no dribbling is caused, and owing to the rapidity with which pressure is destroyed, there is no unequal side pressure upon the plunger—a very important point; and injection pressures up to and exceeding 300 atmos. can be obtained and maintained for unusually long periods, owing to the unbroken cylindrical surface of the plunger and equalized radial pressure eliminating wear.

In order to time the moment of injection a controllable coupling described and illustrated in the original article is provided. (*The Commercial Motor*, vol. 53, no. 1355, March 3, 1931, pp. 88–90, illustrated, *d*)

An Automotive Oil Engine Operating With Accelerated Combustion

AN OIL engine of high specific capacity based on a combustion system with novel features has been developed to the commercial stage by F. Oberhaensli & Cie and is now being used for powering "Vomag" motor trucks of the Vogtlaendische Maschinenfabrik.

Although the new combustion system is reported to have been applied to cylinders of various sizes, some of them running at speeds up to 2500 r.p.m., the engine for the Vomag 5-ton trucks operates at 1350 r.p.m. and normally develops 80 b.hp. in four cylinders with a maximum overload capacity of 100 b.hp. With the bore and stroke dimensions given as 5.118 × 7.087 in., the corresponding piston speed is 1595 ft. per min., and the mean effective pressure 80.3 lb. per sq. in. The weight of the engine is given as 1233 lb., according to which its weight per horsepower would be 15.4 lb. It is stated that the design of the engine follows conventional lines characteristic of motor-truck power plants, and that no special effort was made to reduce weight. Major emphasis is said to have been placed on the combustion system, which is stated to be equally applicable to all types of engines belonging to this range of sizes. The low maximum pressures attributed to the system of combustion are claimed to make it particularly suitable for engine designs in which reduction of weight is a principal consideration.

Researches to determine the scientific basis of the combustion method are being conducted by Dr. Kurt Newmann, professor at the Hanover Technical College and a leading authority on Diesel technology. Although this work is still in progress, Dr. Neumann feels that it justifies a belief in the ability of the new system to operate at high mean effective pressures and speeds of combustion with a clean exhaust and more than usually satisfactory general engine conditions. He is said to be supported in this view by Dr. A. Naegel, of Dresden, member of the governing committee of the Society of German Engineers. Road tests conducted during the past few weeks by Vomag engineers have included operation of the vehicle on heavy grades with platform loads exceeding $5^1/_2$ tons. The results are said to have confirmed Dr. Neumann's technical estimate. (Abstracted from news release through *Diesel Power*, vol. 9, no. 2, Feb., 1931, p. 76, 2 fig., *d*)

MACHINE PARTS (See Mechanics: Engine Valve Springs)

MATERIALS OF CONSTRUCTION

The Tough-Hardness of Steel

THE author states that to provide a steel part which will last a long time and resist strains to which it is subjected, the property of tough-hardness must be present, and that engineering data are meager on this point. Hardness as measured by the scleroscope and Brinell machines has been used as a measurement of the property required in steel for long-wearing service, but is not the right kind of an index for this purpose. The hardest steels are the most brittle, and when used in such articles as bearings or gears do not last as long as parts in which the hardness is drawn out. It is common practice to test for hardness such moving parts of machinery as crankshafts, camshafts, etc., when really knowledge of the wearing properties is sought. Bronze gears have been found to outwear steel gears when running in mesh with them, yet hardness testing would indicate that steel gears are better.

The author claims that hardness-testing machines are not very accurate and that it is difficult to check one machine with another, particularly when the two are of different types. As an illustration of the uncertainty of such readings he cites the case of two connecting rods which were tested all over their surface and, while they were produced in the same way, showed a wide variation in hardness.

He comes to the conclusion that at present probably the best indication of tough-hardness can be obtained from the readings on the Upton-Lewis type of fatigue-testing machine, as that property would be the greatest factor in the resistance to fatigue. Some engineers use reduction of area as a criterion of the tough-hardness with fair results, while others use it in combination with elongation, or elastic limit, or both.

Impact tests, either of the Charpy or Frémont type, give a good indication of the toughness that is a property of the softer steels, but not of the tough-hardness that is desired for such parts as gears, crankshafts, connecting rods, etc. This is shown by the fact that the highest impact figures are obtained when the steel has been hardened and then drawn at a temperature of 1300 deg. fahr. From a drawing temperature of 500 deg. fahr., to one of 900 deg., a gradual decrease in impact test figures occurs, and from 900 to 1300 deg. fahr. a gradual increase is noted. Steels which are cooled slowly in a furnace give higher impact readings than those cooled in air or quenched in water, the water-quenched steels being the lowest. This is the direct opposite of the readings obtained with a Brinell hardness tester.

Steels for use in moving parts of machinery usually show best results when hardened correctly and drawn at temperatures between 700 and 800 deg. fahr.

The finer the grain of a steel, the greater will be its tough-hardness. As chromium refines the grain of steel more than any other element, this property of tough-hardness is greater in the chromium alloys than in any of the other metals or alloys. This is also true of other physical properties, either static or dynamic. An addition of nickel still further increases the values of physical properties, as it neutralizes the mineral hardness produced by the chromium and makes the alloy more easily machinable. It also reduces the grain to one that is more amorphous. This gives the chrome-nickel steels a tough-hardness that is greater than can be found in any of the other straight or alloyed steels. (E. F. Lake, Consulting Metallurgist, Marysville, Mich., in *Steel*, vol. 88, no. 13, Mar. 26, 1931, pp. 42–44, illustrated, *p*)

MECHANICS

Vector Method of Studying Mechanical Vibrations

THE author applies to the study of mechanical vibrations essentially the same methods of vector analysis that are commonly used in the study of alternating-electric-current phenomena. He analyzes the elements of vibration and develops a vector nomenclature applicable to the phenomena of mechanical vibrations. From this he proceeds to a general discussion of the clock vector diagram, as well as of such vector mathematics as vector additions, and displacement velocity and acceleration vectors. This lays the foundation for a study of simple harmonic vibrations and the shrinking sine vibration. The article is interesting but not suitable for abstracting. (First two instalments of a serial article by Prof. David Robertson in *The Engineer*, vol. 151, nos. 3920 and 3921, Feb. 27 and Mar. 6, 1931, pp. 230–231 and 256–257, illustrated, *mA*)

Engine Valve Springs

CONSIDERABLE trouble has been experienced by the failure of engine valve springs. These springs are of small volume for the duty they have to perform, and in consequence the stresses are high and only the best and most reliable steels can be used. Fractures are usually caused by fatigue and occur mainly at the end coils of the springs where, because of surging effects, the stresses are highest. Surging, as actually measured, may increase the normal or designed stress by 45 per cent.

A preliminary investigation was devoted to obtaining the torsional fatigue range of steel wires suitable for springs, but was later extended to explore the discrepancies, and to some extent the reason for the discrepancies, between the torsional fatigue strength of the wires and the much higher fatigue strength of the material itself when surface defects were removed. The tests were made by subjecting the wires to fluctuating torsion, and the range of stress was chosen so that the minimum and maximum stresses were in the ratio of 1 to 4. This range is representative of the highest duty experienced by engine valve springs. All the wires were of No. 8 I.W.G.

Tests were made on several steel wires commercially supplied to British Engineering Standard Specifications and including low- and high-carbon, silicon-manganese, and cold-drawn carbon steel wires, and the fatigue ranges were determined on the wires as received, and after undergoing heat treatments where applicable. The results of the tests were disappointing and the fatigue ranges were generally of a low order; fractures appeared to be initiated by some serious defect on the surface, and in consequence the wires were apt to be erratic and unreliable in behavior.

At a later date some especially prepared wires were obtained, as, for example, a chrome-vanadium steel wire which had been manufactured by rolling down to $^9/_{16}$ in. diam., grinding the surface off until the diameter was $^7/_{16}$ in. to remove defective material, and then finally drawing down to the size required. The results obtained from these wires were superior and more consistent than from earlier wires and the fatigue range was considerably increased. This particular steel could withstand for a very long period a stress range in torsion of $9^1/_2$ to 38 tons per sq. in.

Further torsional fatigue tests of some of the wires were made after the surface had been removed by varying amounts so as to remove any defects present, and the results were most marked, the increase in fatigue range being very considerable. Consistent improvement was noticeable as each few thousandths of an inch were removed, until apparently the surface defects were practically eliminated.

The general conclusion drawn from the investigation is that by care in preparation a reliable and high-quality steel wire can be obtained. Of more importance, however, is the fact that the fatigue qualities of a wire are much less than can be obtained from a test specimen ground from the same wire, and it is quite conceivable that a further 50 per cent improvement is available in the material.

The paper includes detailed particulars of the materials and test results, with a table of the dimensions and stresses obtaining in standard valve springs. Diagrams are included to show the effect of surging and typical fractures are illustrated. Curves are also given which show the stress range permissible in the various wires tested and the improvement to be obtained by removing surface defects in the wire. (Messrs. Swan, Sutton, and Douglas, in a paper entitled "An Investigation of Steels for Aircraft-Engine Valve Springs" presented before the Institution of Mechanical Engineers, London, Feb. 20, 1931; abstracted through *The Engineer*, vol. 151, no. 3920, Feb. 27, 1931, p. 231, *e*)

MOTOR-CAR ENGINEERING

Thermostatic Control of Crankcase Oil

THE author considers this a much-needed development. When the internal-combustion engine is started, good lubrication must be immediately provided to all of its parts. Had the lubricant been properly varied with the season and means provided for maintaining it at proper temperatures, this condition could be very easily satisfied. Actually cold lubrication of the engine depends entirely upon the crankcase oil's having proper physical characteristics, and its delivery to the bearings and cylinder walls depends as much upon its viscosity at the crankcase temperature as upon the more generally accepted pour-point criterion.

A series of dynamometer tests were made in the latter part of 1928 with a large poppet-valve bus engine and a sleeve-valve passenger-car engine. From these tests it appears that a partial solution of the starting problem is to use very low-viscosity oils or to accomplish the same thing by either prediluting higher-viscosity oils or preheating the latter.

However, diluted oils are not desirable after the engine is warmed up. This immediately suggests a favorite trick used before self-starters were in general use, namely, stopping the engine with the choke. By so doing the gasoline sucked into the various cylinders will dilute the oil on the cylinder walls, thereby reducing the starting effort required next morning without excessively diluting the crankcase oil. As a matter of fact, such procedure really reduces the amount of choke required the following morning. In stopping the engine by this method, it should first be idled and then stopped by pulling out the choke. After this operation is completed the ignition should, of course, be shut off to avoid discharging the battery. This method is not proposed as an ideal solution, but merely as a practical means in cases where other methods cannot be employed.

From another series of tests it would appear there is a tremendous difference in the starting ability of different cars. For example, it is permissible to use an oil of as much as 80,000 sec. Saybolt viscosity at the starting temperature in car 1, yet in cars 4 and 5 trouble would be encountered if the crankcase-oil viscosity were higher than 25,000 sec.

After describing certain pumping experiments the author gives the following summary of his work:

1 Gasoline of reasonable volatility will permit easy starting, provided other factors are correct.

2 The relation of friction horsepower to starter horsepower and engine power at low speeds is the real controlling factor. It is important for the manufacturer to so design his engine and starting equipment that as soon as firing occurs the power developed will be sufficient to not only kick out the starter but to maintain operation and rapidly accelerate the engine.

3 The viscosity of the crankcase oil at the starting temperature is of great importance. Regardless of what the manufacturer should do, this viscosity must be low enough to permit the engine as designed to carry the friction load as soon as it fires. Otherwise the engine will die.

4 It has been shown that a motor oil which will give first-class starting results in a given car may be entirely unsuited for a second car under the same winter temperatures.

5 The most adverse starting conditions are encountered immediately after charging the engine with fresh oil. After several days' operation sufficient dilution of the crankcase oil occurs to reduce materially the starting effort required.

6 It is suggested that crankcase oils be changed if possible on warm days, so that they may have a chance to reach dilution equilibrium before the next cold day arrives.

7 Every operator should realize that it is important for him to make certain that his starter, battery, ignition system, spark plugs, gap settings, and carburetor adjustment are correct. If more attention were paid to these factors much less starting trouble would be encountered when cold weather arrives.

8 After starting a cold engine it should be allowed to idle until lubrication is fully established. Otherwise bearings and cylinder walls may be scored.

9 It is not necessarily true that low-pour-point oils will establish lubrication more rapidly than high-pour-point oils. The viscosity of the oil at the crankcase temperature is as important as the pour point. (Dr. A. E. Becker, Standard Oil Development Co., in a paper presented before the New England Section of the Society of Automotive Engineers; abstracted through *Automotive Industries*, vol. 64, no. 10, March 7, 1931, pp. 401–405 and 415, 8 figs., *ep*)

POWER-PLANT ENGINEERING

The Columbus Pan Ash Separator

A SEPARATOR used for the recovery of coke or combustible material from the ashes relies on their relative specific gravities as a basis of separation.

The Columbus separator, Fig. 6, consists of two main parts, a revolving sieve drum *B* into which the ash is fed through the orifice *A*, and the separator proper. The process is briefly as follows:

The material passes through the revolving mesh-sieve drum *B* to remove the fine dust, and through a revolving large-meshed grid *C*, any occasional oversize (the elimination of which is desirable, consisting mainly of pure slag of no calorific value) being passed out through the chute *E*. From the grid *C* the material drops into the separator chamber *F*, within which revolve, in separate chambers, two superimposed conveyor worms *G* and *H*. The container is half full of water, the specific gravity of which has been increased to about 25 or 30 deg. by any of the numerous means readily available, such as the admixture of common clay, loam, chalk, carbide lime, or salt lye. Upon falling into this liquid the heavy slag immediately sinks to the bottom, while the lighter coke floats on the surface. The upper conveyor worm *G*, which projects well into the liquid but does not reach the bottom of the tank, picks up the coke only and takes it to the chute *K*. The lower conveyor worm *H*, on the other hand, is carried down to the tank bottom, picks up the slag and stones only, and passes them out through the separate chute *L*.

The two worms *G* and *H*, as well as the revolving sieve drum and the elevator, are all driven from one main driving shaft, from 1 to 4 hp. being absorbed according to the size and output of the machine. The water consumption is 20 to 50 gal. per hr.; any waste water, fresh or salt, can be used.

Both the coke and the slag are immediately available for use. The coke, having become only superficially moistened, can at once be re-fed into a furnace. As the coke becomes slightly coated with clay, a washer and grader can be attached to the separator to remove all traces of discoloration when the coke is for sale and not to be consumed at the works.

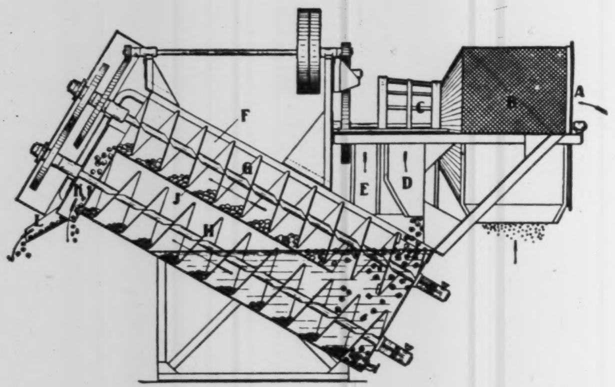

FIG. 6 SECTION THROUGH COLUMBUS PAN ASH SEPARATOR

In spite of the fact that the coke is sometimes immersed twice, once in a separator and once in a washer, if lumps of the coke are broken open it will be seen that the water has not penetrated into the structure at all, as the period of immersion is extremely short and no force of water is required as in the case of an impulse washer.

Fig. 1 in the original article (not reproduced here) shows the arrangement of a medium-sized plant complete with pit and feeding elevator. (*Mechanical Handling*, vol. 18, new series I, Jan. 13, 1931, pp. 11–12, 3 figs., *d*)

Loads on Pulverized-Coal-Fired Furnaces

IN DESIGNING a pulverized-coal-fired furnace the first question that arises is that of normal load. It cannot be chosen arbitrarily any more than can the output of an engine cylinder having a given stroke volume. Formerly the matter of load was one determined purely by experience of the designer, and where a new type was involved the designer had to depend on analogy. This naturally led to a number of erroneous designs and indicated the need for an analytical method for the determination of this load, which is what the author attempts to do. He quotes papers Nos. 1956 and 2024 of the A.S.M.E. Transactions presenting the methods proposed by Professor Wohlenberg and his collaborators, but claims that his method is different as he bases his calculation deliberately on the flame conditions and not the heating area, and attempts to base the behavior of the boiler on the dynamic thermal equilibrium between combustion and heat transfer. It is only quite recently that a base for such an investigation has been provided by the theory of the process of combustion proposed by Staub (compare *Zeitschrift des Vereines deutscher Ingenieure*, 1930, no. 13, p. 395).

The specific load on a furnace is the number of calories that can be generated in it per hour per cubic meter of volume, assuming complete combustion without any residue and including the heat originating in preheating. The specific load is measured in kilogram-calories per cubic meter per hour. The total load is the corresponding amount of heat generated in the entire furnace and is measured in kilogram-calories per hour. According to our present knowledge the following factors limit the load capacity on a furnace:

I—Relating to the proper combustion of fuel: 1, Its combustion characteristics; 2, technique of its combustion; and 3, fusibility of its ash.

II—Relating to the boiler: 1, The ability of the heating surface to absorb heat; and 2, the mechanical, thermal, and chemical stressing of the material.

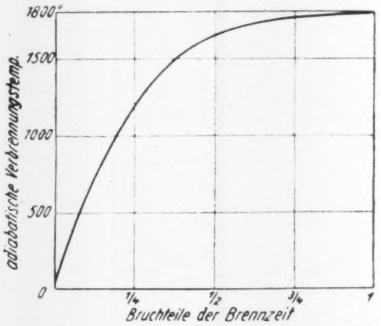

FIG. 7 ADIABATIC-COMBUSTION TEMPERATURE AS A FUNCTION OF TIME

[Bituminous coal, lower heat value 7000 kg-cal. per kg. (12,600 B.t.u. per lb.); 25 per cent excess air; ordinates; adiabatic; combustion temperatures in deg. cent.; abscissas; fraction of burning time.]

At first engineers had to combat the limits imposed by the speed of combustion obtainable, and every effort was directed toward increasing this speed. However, the problem has now been solved to such an extent that the attainable speed of combustion far exceeds the permissible speed. The increase of speed of combustion is today still an outstanding problem only in the case of very small, effectively cooled furnaces operating on lean fuels.

In the case of large furnaces the determining factors today are the properties of the ash and the heat transfer at a given load capacity. The fine ash must be cooled below its softening point before it comes in contact with the heating surfaces, and this cooling takes place to the extent to which the ash can radiate its heat. This is the crux of the problem. The dynamic thermal equilibrium in the furnace is determined by the equation:

Heat transfer to the heating surface (in kg-cal. per hr.) = thermal efficiency × total furnace loading (in kg-cal. per hr.)

where the thermal efficiency is determined by the temperature drop in the fire chamber. The author assumes that the heat in the furnace is transferred exclusively by radiation. In the region of high temperatures there is all the more justification for such an assumption as the flame is kept as far as possible from the walls of the furnace in order to avoid clinkering. On the other hand, the question as to what is the temperature of radiation, i.e., the average temperature which corresponds to the actual value of the heat of radiation, has hitherto been answered only in a rather unsatisfactory manner. This temperature must obviously lie between the adiabatic temperature of combustion and the temperature actually attained under conditions of dynamic equilibrium. The actual conditions are best approached if we define as the temperature of radiation the geometric mean between these two values. The upper limit, i.e., the adiabatic temperature of combustion, is here by no means constant but is a function of time, depending on the combustion process of the pulverized fuel (Fig. 7).

The desired relationship between the generation of the flame and the heat transfer is in the first approximation determined by this time function. The author discusses this subject in detail in Appendix No. 2 of the paper, in which among other things he develops the fundamental equation for the dynamic thermal equilibrium. This part is not abstracted here because of lack of space, but it enables us to consider analytically the relationship at the equilibrium between the load "beginning with the fuel" as produced by the combustion and the load "beginning with the boiler" as determined by the heat transfer. Both are functions of temperature, time, and volume, and it is only where these functions have equal values that equilibrium is obtained. The creation of certain definite temperature conditions in a given furnace makes it possible to attain a given loading capacity. These equilibrium calculations permit us to establish what factors determine the load capacity, and to what extent. As such factors the author considers, first, the influence of the furnace, its dimensions and shape; second, the influence of the heating surfaces, their dimensions and temperature; and third, the influence of the combustion process, which comprises admission of air and time taken for combustion.

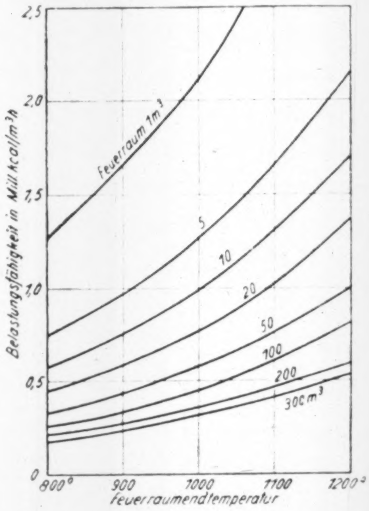

FIG. 8 INFLUENCE OF DIMENSIONS OF A FURNACE OF CUBICAL SHAPE ON ITS LOADING CAPACITY

[Ordinates, loading capacity in millions of kg-cal. per cu. m. per hr. (to obtain values in millions of B.t.u. per cu. ft. per hr. multiply by 0.112); abscissas, end temperature in the furnace (*Feuerraum* = volume of furnace).]

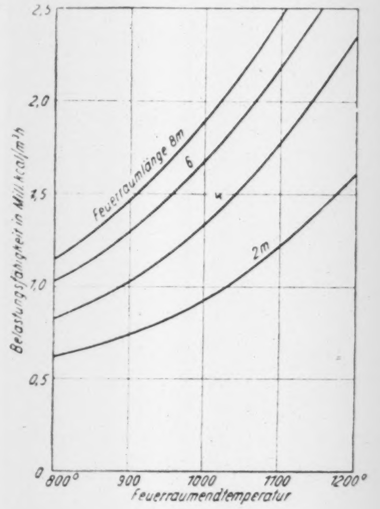

FIG. 9 INFLUENCE OF SHAPE OF FURNACE ON ITS LOADING CAPACITY, ASSUMING TOTAL FURNACE VOLUME TO BE 8 CU. M.

[Ordinates, loading capacity of furnace in millions of kg-cal. per cu. m. per hr. Abscissas, end temperature of furnace, deg. cent. (*Feuerraum länge* = length of furnace.)]

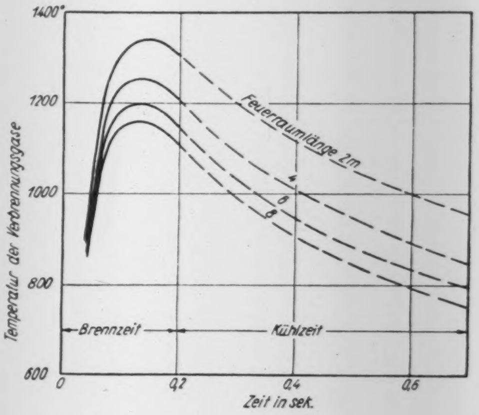

FIG. 11 TEMPERATURE VARIATION IN FURNACES OF DIFFERENT SHAPE BUT WITH THE SAME TOTAL VOLUME OF 8 CU. M.

[Ordinates, temperature of gases of combustion. Abscissas, time in seconds. (*Feuerraum* = volume of furnace; *Brennzeit* = duration of combustion; *Kühlzeit* = duration of cooling.)]

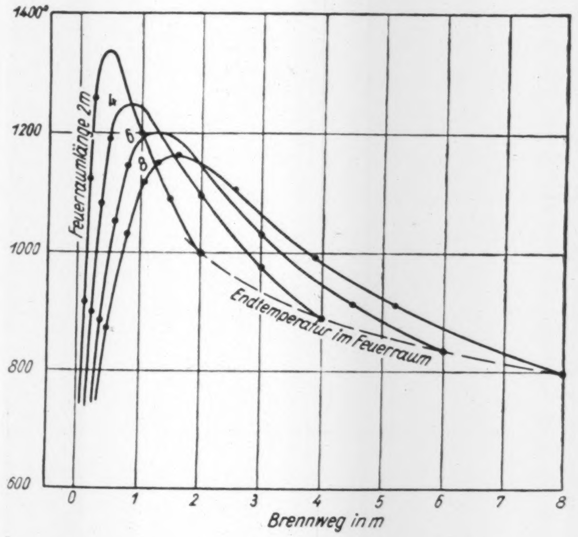

FIG. 10 VARIATIONS OF TEMPERATURE IN FURNACES OF DIFFERENT SHAPE BUT ALL OF A TOTAL VOLUME OF 8 CU. M.

[Abscissas, length of path of combustion in meters. (*Feuerraum länge* = length of furnace; *End Temperatur im Feuerraum* = final temperature in the furnace).]

INFLUENCES OF THE FURNACE

Dimensions. The vital importance of this factor is shown in Fig. 8. The permissible load falls off rapidly with an increase of the dimensions of the furnace, bringing about an increasingly unfavorable relationship between heating surfaces and volume. Practice has already clearly established that in large boilers only comparatively low loading can be used, while in such small furnaces as those used in locomotives and on shipboard the high outputs are not only permissible but actually necessary. Most kinds of ash unfortunately become dangerous at temperatures about 900 deg. cent. The top temperature in the furnace must therefore observe this limit in order to avoid clinkering on the furnace walls. As a result the firebox of a locomotive with a volume of 5 to 6 cu. m. (176.5 to 211.8 cu. ft.) must not be loaded beyond 1,000,000 kg-cal. per cu. m. per hr. (1 cal. per cu. m. = 0.112 B.t.u. per cu. ft.), while the furnace of a large boiler with an output of 100 tons of steam will not stand a load of more than 200,000 kg-cal. per cu. m. per hr. The load capacity of a furnace increases very rapidly with increase of permissible top temperature. If the ash softens at 1000 deg. cent. instead of 900 deg. cent. the output of the furnace may be increased by from 25 to 30 per cent, which indicates what a tremendously important key position the ash occupies.

Shape of Furnace. If instead of a cubical fire chamber an elongated shape is selected there will be more cooling surface for the same volume. The working of an 8-cu. m. (282.4 cu. ft.) furnace is shown in Fig. 9. When the chamber is increased in length from 2 m. to 4 m. (6.56 to 13.12 ft.), the loading capacity, depending on temperature, increases from 35 to 50 per cent. This affords great and as yet untapped possibilities. For example, one might contemplate a design in which large fire chambers are divided into a battery of smaller and longer chambers opening into one larger boiler. It has been well known for a long time that large single furnaces are not practical, and engineers have not hesitated to divide them up into several units. Such a subdivision of large furnaces into several units would have advantages from the point of view of the technique of firing, as the problem of supply of secondary air could be easier solved by this method. This problem is primarily one of mixing, and large volumes mix together in a less satisfactory manner than small ones.

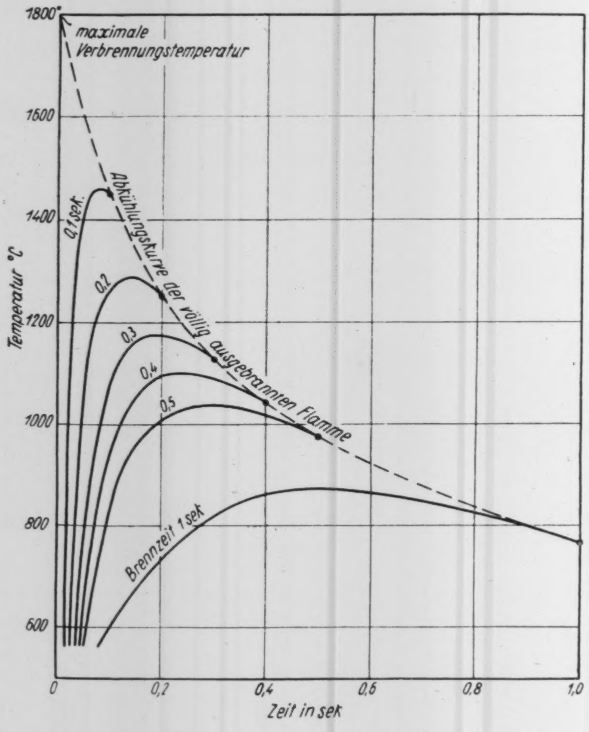

FIG. 12 TEMPERATURE VARIATION WITH POWDERED COALS OF DIFFERENT BURNING TIMES IN A FURNACE OF 8 CU. M. TOTAL VOLUME COOLED ON FIVE SIDES

[Ordinates, temperature in deg. cent. Abscissas, time in seconds. Upper left-hand corner point shows maximum temperature of combustion; lowermost solid curve, duration of combustion of 1 sec.; broken-line curve is a curve of cooling of the completely burned-out flame.]

Figs. 10 and 11 show the temperature variation of these furnaces with time for a total combustion period of 0.2 sec. One can see the typical sharp rise and slow falling off of this curve. With the extension of the furnace to a length of 4 m. (13.12 ft.) the top temperature goes down from 1340 to 1250 deg. Still more interesting is the improper ratio between the given combustion period and the necessary period of cooling. The total time at 1000 deg. in a furnace 4 m. long must be twice as great as the combustion period. In operation this difference is utilized by coarser pulverization, and it constitutes the necessary reserve in case of variations of load. In any event it appears that wherever the combustion is completed before the fuel enters the region of the "convection heating surfaces," the temperature constitutes the deciding factor in the matter of load capacity on the furnace.

The author discusses next the influence of the size and temperature of the heating surfaces, and then proceeds to deal with the process of combustion itself. He considers first the excess air and points out that with purely primary air operation the influence of excess air is a threefold one: 1, If the temperature of combustion and hence the total temperature level sinks, the loading capacity increases; 2, if, however, the smaller drop of temperature results in a poorer carrying off of the heat, then the loading capacity of the furnace decreases; and, 3, with an increase of excess air the volume of flue gases increases, and this again leads to a falling off in loading capacity.

Combustion Period. Fig. 12 shows the time-temperature relation for powdered fuels of various speeds of combustion, the graph clearly showing how with a decrease in duration of the combustion the flame becomes shorter and hotter. It also shows that small and powerfully cooled furnaces not only make it possible to reduce the duration of combustion, but actually make it imperative. This is so because for a combustion period of one second the highest equilibrium temperature is only about 900 deg. cent. which does not insure steady operation as the flame is interrupted at the least disturbance. Because of this, assuming complete combustion, it is important to note that the final temperature depends essentially only on the total length of the combustion period. Fig. 13 shows the functional relation between duration of combustion on the one hand and capacity for handling loads on the other. According to this figure the increase in load capacity is not proportional to the reduction in the combustion period, because cutting this in half produces not a double loading but only one 1.6 to 1.7 times the original loading. This is due to the higher temperature level with the shorter duration of combustion, and to the fact that it partly cancels the gain from the shorter duration of combustion by developing a greater volume of gases. From this figure it also appears that the loading capacity increases

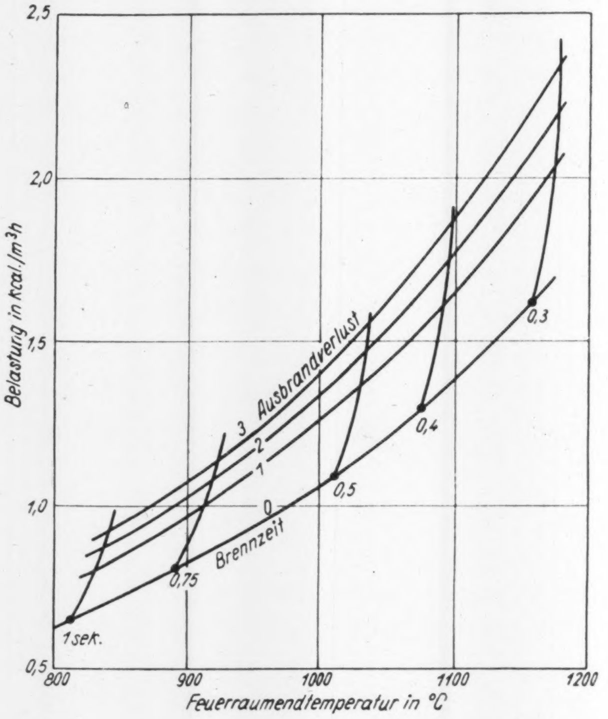

FIG. 13 INFLUENCE OF DURATION OF COMBUSTION AND COMPLETE COMBUSTION ON THE LOADING CAPACITY IN THE CASE OF A FURNACE OF 8 CU. M. TOTAL VOLUME

[Ordinates, loading in kg-cal. per cu. m. per hr. (To translate into B.t.u. per cu. ft. per hr. multiply by 0.112.) Abscissas, end temperature in the furnace in deg. cent. Curve 0, duration of combustion; curve 3, loss in complete combustion.]

tremendously when there is a small percentage of unconsumed fuel, the increase being for 1 per cent fuel, 25 per cent; for 2 per cent, 35 per cent; and for 3 per cent, 45 per cent. In practice this kind of load reserve can be utilized only where the fuel is very cheap and facilities are provided for removing the dust from the stack gases. From this the author proceeds to a consideration of the matter of air supply as affecting the capacity of the furnace to handle loads.

COEFFICIENT OF RADIATION

What the coefficient of radiation of a pulverized-coal flame is, is as yet not at all clear. The main point is that it is not a coefficient of radiation of individual solid particles of fuel or ash that matters, but the integrated value for the radiation from all the millions of heat-radiating solid and gaseous particles, in other words, the coefficient of flame radiation. From what we know of the laws of distribution of particles of solid fuel, their reduction in surface area during combustion and gas radiation, the integrated value, which comprises both the degree of blackness and the radiating areas, may be represented by a complex function of at least seven independent variables, namely, fineness, volume of exhaust gases, ash content of the powdered fuel, temperature of gas, time, absolute dimensions of the furnace, and distance from the heating areas. The derivation of this formula is given in Appendix No. 3 to the original article, which cannot be reproduced here because of lack of space. It is stated, however, that this function leads to interesting conclusions as to the nature of the flame, and it has been evaluated in Fig. 14 for the case of a firetube boiler 1 m. (3.28 ft.) in diameter.

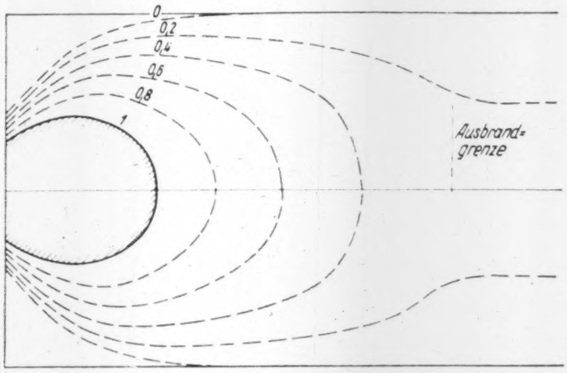

FIG. 14 DEGREE OF BLACKNESS OF FLAME 1 M. IN DIAMETER
(*Ausbrandgrenze* = boundary of complete combustion.)

In this case there are grouped around the burner a number of curves of an elliptical nature indicating equal degrees of blackness of the flame. The outer layer represents a zero value, in that right at the burner there forms a fairly large core, the internal portion of which gives up no heat to the heating surfaces because the layer of flame surrounding it radiates black and is therefore not transparent to radiation. To the extent to which combustion progresses the flame becomes rapidly transparent and the coefficient of radiation decreases until the coal dust has been completely consumed, and then remains approximately constant.

Particular attention is called to the small thickness of the layer transparent to radiation at the beginning of combustion. It is only after it has traveled about one-third of the combustion path that the inside of the flame begins to be affected by the cooling influence of the wall, and after complete combustion it attains only about 70 per cent of the maximum radiation capacity. This figure explains many phenomena which have been observed in powdered-coal flames. Thus, for example, the ignition of the air-powdered-coal mixture takes place from the edges inward, because the inward-bound radiation from the hot brickwork of the furnace does not penetrate to the core. On the other hand, this non-transparent layer acts as a jacket, protecting the core of the flame from giving up radiation and thereby facilitating reignition. It follows from this that large single burners require longer paths for ignition than do group burners of the same combined capacity.

Another way to reduce the time of ignition is by reducing turbulence in the primary powdered-coal-air mixture. It should be borne in mind, however, that the radiation characteristics of a flame depend on the size of the furnace, as indicated by two diagrams in the original article. Among other things mentioned in this connection is the conclusion of the author to the effect that larger furnace dimensions induce stronger wall cooling, and that the larger the flame, the more elastic it becomes. Because of all these factors it is impossible to apply directly experience with small furnaces to large ones.

FLAME ISOTHERMS

By introducing values for the coefficient of radiation as they vary in time and space into the fundamental equation which the author has previously derived for dynamic thermal equilibrium, graphs are obtained showing the functional connection between the distribution of temperature and the coefficient of radiation (Fig. 15). These graphs apply only to the case of the axis of the flame cylinder. Because of the radiation-protective effect of the outer flame jacket the temperature rises very rapidly and reaches its maximum at the moment when the intensity of radiation begins to fall off. This decrease in radiation is also in clear functional relationship with the coefficient of radiation, which attains its minimum at complete combustion. It is of interest that from that point it begins to increase, though slowly. This is due to the cooling, which leads to an increase in size of the ash particle and increase in molecular density. It would appear, therefore, that the coefficient of radiation when referred to the heating area is, both for solid and for gaseous radiation, inversely proportional to the temperature. A very plausible explanation of this fact seems to offer itself. The gas follows the Gay-Lussac law, and this taken together with the Avogadro law means that the number of radiating particles in a unit of space must be inversely proportional to the absolute temperature. From this an approximate conclusion may be reached covering the case of solid flame radiation by substituting dust density for molecular density. The author claims that in many cases this way of considering the facts leads to a simplification of calculation of flame radiation and permits an immediate comparison between solid and gaseous radiation. If now the velocity field of a gas stream at the exit from a nozzle is taken into account, the true

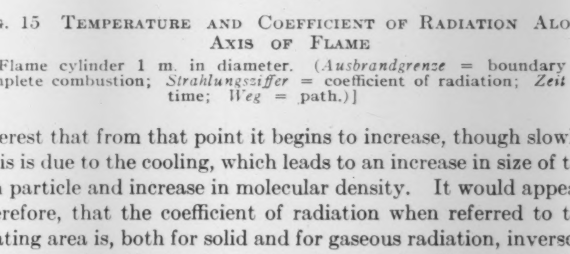

FIG. 15 TEMPERATURE AND COEFFICIENT OF RADIATION ALONG AXIS OF FLAME
[Flame cylinder 1 m. in diameter. (*Ausbrandgrenze* = boundary of complete combustion; *Strahlungsziffer* = coefficient of radiation; *Zeit* = time; *Weg* = path.)]

flame isotherms are obtained as shown in Fig. 16. It would appear that each open powdered-fuel burner has an ignition zone of its own, i.e., a zone of temperature in which the eye does not yet detect any phenomena of firing. By calculation it can be shown that this zone is determined practically exclusively by the velocity field. Around this comparatively cold zone as a jacket is a hotter zone having its maximum temperature at the tip of the flame. Of interest is the location of the "complete combustion boundary," which show how far the tip of the flame in the case of an open tubular burner runs ahead and how badly this affects the utilization of the furnace space. This boundary may be considered as an important index as regards the difference between fire-chamber loading and flame loading. For example, if the stack gases with the same amount of powdered fuel and air leave the fire chamber with a temperature of, say, 1000 deg. cent. (1832 deg. fahr.), the loading on the fire chamber is constant, entirely independent of the appearance of the temperature process and hence entirely independent of the flame loading as such. The volume of the flame is inversely proportional to the velocity of combustion. This is not important for the determination of the dimensions of the fire chamber and the cooling areas, but extremely so for the proper distribution of the brickwork, the heating areas, and the matter of selection of materials. This is due to the fact that the flame load affects that property of pulverized-coal flame which we might call "thermal hardness." The higher the flame load the greater are the stresses on the materials of which the furnace is constructed.

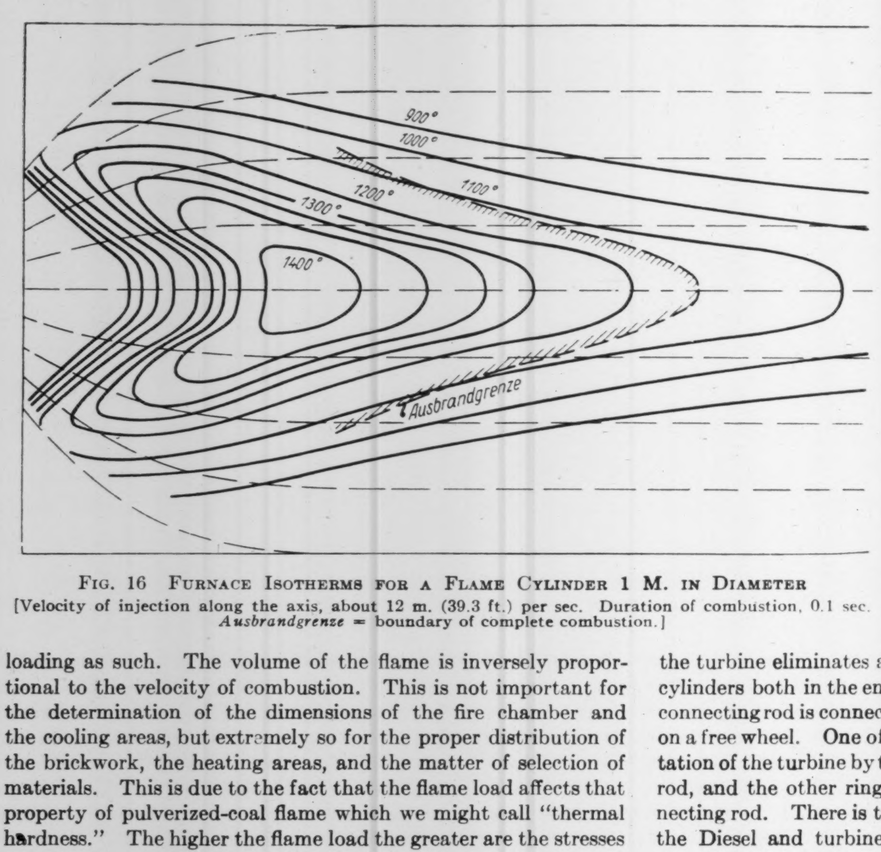

Fig. 16 Furnace Isotherms for a Flame Cylinder 1 M. in Diameter

[Velocity of injection along the axis, about 12 m. (39.3 ft.) per sec. Duration of combustion, 0.1 sec. *Ausbrandgrenze* = boundary of complete combustion.]

Rapid rise of temperature is followed by a slow cooling which is characteristic of all exothermal surface reactions. The further the combustion proceeds the further are the isotherms extended in the axial direction, which means that the laws of radiation practically govern the graph.

The author claims that this astounding agreement between calculation and experience is of very great value, inasmuch as it affords the possibility of predetermining in advance the action of a flame, and is of valuable assistance to the designer in laying out his firing plant.

The article is followed by three appendixes. In the first, a general determination of the flame, the author considers the powdered-coal flame as a suspension of burning particles of pulverized coal in the air and gases of combustion. It is therefore a burning core and not a gas medium which is the starting point for all radiation and combustion phenomena.

The second appendix is devoted to the development of the fundamental theory of dynamic thermal equilibrium and its application to the problems of: (*a*) heat transfer to the heating areas in the furnace; (*b*) development of heat in the firing chamber; and (*c*) conditions of equilibrium.

The third appendix deals with the coefficient of radiation in the case of solids and gases, as well as with the matter of transparency to radiation. (P. Rosin and R. Fehling in a paper presented on May 22, 1930, to the Pulverized Coal Board of the Federal Coal Council, at a joint meeting of the Committee of Investigation of Combustion Problems of the Federal Coal Council and the Subcommittee on Boiler Firing of the German Society of Engineers; read before latter body in Dresden, Nov. 14, 1930, and abstracted through *Die Wärme*, vol. 54, no. 3, Jan. 17, 1931, pp. 42–50, 15 figs., *eA*)

International Congress of General Mechanics, Liege, 1930

A HEAVY-OIL GAS TURBINE

THE heavy-oil gas turbine described in a paper read by M. Brasseur at the Congress is a combination of a two-stroke-cycle double-acting Diesel engine and a turbine with three velocity stages. The groups of two cylinders in the Diesel are remarkable in that they have a single connecting rod with two pistons located at the ends of the connecting rod and without any connection to the turbine disk. A single reciprocating movement of the straight-line connecting rod running in two guides insures the different phases of the Diesel cycle for each group of two cylinders located along the same axis. This connecting rod carries with it the connecting rods of a four-cycle compressor providing injection air and air for starting. The absence of connection between the engine pistons and the turbine eliminates all lateral thrust of the pistons against the cylinders both in the engines and in the compressors. The engine connecting rod is connected to the turbine by a double ring mounted on a free wheel. One of these rings is carried in the direction of rotation of the turbine by the right-hand side of the engine connecting rod, and the other ring by the left-hand side of the engine connecting rod. There is therefore a complete independence between the Diesel and turbine sides of the installation. The turbine proper is mounted on the engine crankshaft and concentric to the bucket wheel is mounted the ring of turbo-compressors furnishing the scavenging air for the Diesel cylinders. The water pump with two circular radiators provides cooling water for the Diesels and compressors. The Diesel cylinders are set in pairs all around the periphery of the turbine and in such a number as would make it possible to increase the power without modifying in any essential way the turbine parts. As soon as the turbine is started the connecting rods first carry the turbine disk; then as the velocity of the gas increases the connecting rods come into play less and less, and finally act merely as a reservoir to feed hot gas to the turbine. The number of back-and-forth strokes of the engine connecting rod increases until an equilibrium is established between the engine work and the work of resistance consisting chiefly in the compression of the engine cylinders and compressors. (*d*)

INVESTIGATION OF STEAM PIPING FROM THE POINT OF VIEW OF ITS ABILITY TO ABSORB THE EFFECTS OF EXPANSION BY ELASTIC DEFORMATION

It is claimed by its author, Henri Carlier, that the present paper gives a general method for determining the elastic ability of steam piping.

1 Case of a Pipe Rigidly Held at *A* and *B* (Fig. 17). The following are the general formulas expressing the elastic ability of the pipe in the two principal directions of the figure or the virtual elastic displacements Ax_B and Ay_B of the end *B* with respect to *A*:

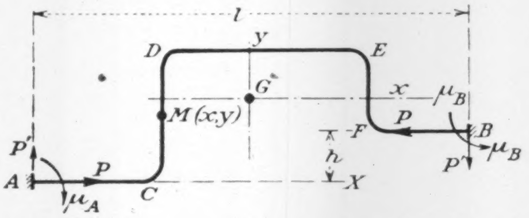

FIG. 17 CASE OF A PIPE RIGIDLY HELD AT BOTH ENDS

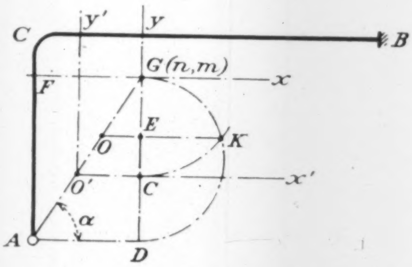

FIG. 18 GEOMETRIC CONSTRUCTION TO DERIVE THE ORIGIN OF AXES x' AND y' IN THE CASE OF A PIPE HELD AT ONE END AND ROTATED AT THE OTHER END

$$\frac{1}{EI}\,(PI_x - P'I_{xy}) = \Delta x_B = l\alpha T$$

$$\frac{1}{EI}\,(P'I_y - PI_{xy}) = \Delta y_B = h\alpha T$$

In Fig. 17, *G* is the center of gravity of the figure and is here also the central point of the elastic system. G_x and G_y are two axes located parallel to the principal directions of the figure. *P* and *P'* are the reactions created by the expansion in the two directions; α is the coefficient of expansion; *T*, difference of temperature; *E*, coefficient of elasticity of the metal of the tube; *I*, moment of inertia of the section of the tube; I_x, moment of inertia of the figure relative to the axis of *x*; I_y moment of inertia of the figure relative to the axis of *y*; and I_{xy} = resultant moment of inertia.

2 Case of a Figure Where the End *A* Undergoes a Rotation α_A While the Other End *B* Is Rigidly Held. The virtual displacements of the point *B* with respect to *A* are expressed by the formulas

$$\frac{1}{EI} = (PI'_x - P'I_{xy}) = \Delta x_B = l\alpha T$$

$$\frac{1}{EI} = (P'I'_y - PI_{xy}) = \Delta\, y_B = h\alpha T$$

The point *O'* determining the origin of the axis $x'y'$ can be determined by the geometric construction shown in Fig. 18. *O* is the central point defined by the condition

$$\alpha_A + \int \frac{Mds}{EI} = O$$

The points *A*, *O*, *O*,' and *G* are on the same straight line. This method permits determining the central point on the direction of the central force together with its properties.

Operating Experience With 1200-Lb.-Pressure Boilers at the Masonite Corporation

IN THE Masonite process wood chips are blown into fiber by the use of steam at a pressure of 1000 lb. per sq. in. In this case, therefore, the high-pressure steam is used for process primarily. Two boilers are available, 1200-lb. pressure Babcock & Wilcox make of the cross-drum, sectional-header type. One of these boilers is fired with wood refuse, while the other is fired with coal by a Westinghouse single-retort stoker. By the end of the year both boilers will have been changed to natural-gas firing.

The following operating experiences have not been previously published. The 2-in. tubes have proved to be more immune to failure due to scale formation than have the heavier-wall $3^1/_4$-in. tubes. This is directly due to the thinner wall sections. Another advantage in favor of the thinner tubes is the lower flue-gas temperatures.

Although condensate from the low-pressure drying system is used for boiler-feed purposes, the boiler feed at times contain 4 p.p.m. of hardness expressed as calcium carbonate. This hardness is chargeable entirely to leakage of the [illegible] steam condensers.

The only tube failure to occur in the past seven months was that of a tube in the bottom row of the second high-pressure boiler. This failure occurred on a Tuesday night, but the boiler was kept operating at 250 per cent of rating until the following Sunday morning. This fact has been proof to the operating personnel that the operation of boilers at this pressure is no more dangerous than the operation of boilers in the lower pressure ranges.

The tube failure previously mentioned was caused by the deposition of a dried-out sludge on the bottom of the lower row of the tubes. Since the boilers were opened for an insurance inspection two weeks before the failure occurred, it is apparent that this could not have been prevented. The boiler was left dry during the two weeks that followed the inspection due to the fact that the mill was not running and the boiler room was shut down, making it impossible to pump up the boilers.

From data in the original article it would appear that the failure was caused by sludge deposits, an analysis of which is given in that article. In order to minimize the danger of hard-scale formation in the high-pressure boilers it was decided to maintain a sodium carbonate alkalinity of between 80 and 130 p.p.m. and a phosphate concentration of from 50 to 100 p.p.m. (E. G. Grady, Steam Engr., Masonite Corp., Laurel, Miss., in *Combustion*, vol. 2, no. 7, Jan., 1931, pp. 47–49, 4 figs., *p*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

flame isotherms are obtained as shown in Fig. 16. It would appear that each open powdered-fuel burner has an ignition zone of its own, i.e., a zone of temperature in which the eye does not yet detect any phenomena of firing. By calculation it can be shown that this zone is determined practically exclusively by the velocity field. Around this comparatively cold zone as a jacket is a hotter zone having its maximum temperature at the tip of the flame. Of interest is the location of the "complete combustion boundary," which show how far the tip of the flame in the case of an open tubular burner runs ahead and how badly this affects the utilization of the furnace space. This boundary may be considered as an important index as regards the difference between fire-chamber loading and flame loading. For example, if the stack gases with the same amount of powdered fuel and air leave the fire chamber with a temperature of, say, 1000 deg. cent. (1832 deg. fahr.), the loading on the fire chamber is constant, entirely independent of the appearance of the temperature process and hence entirely independent of the flame loading as such. The volume of the flame is inversely proportional to the velocity of combustion. This is not important for the determination of the dimensions of the fire chamber and the cooling areas, but extremely so for the proper distribution of the brickwork, the heating areas, and the matter of selection of materials. This is due to the fact that the flame load affects that property of pulverized-coal flame which we might call "thermal hardness." The higher the flame load the greater are the stresses on the materials of which the furnace is constructed.

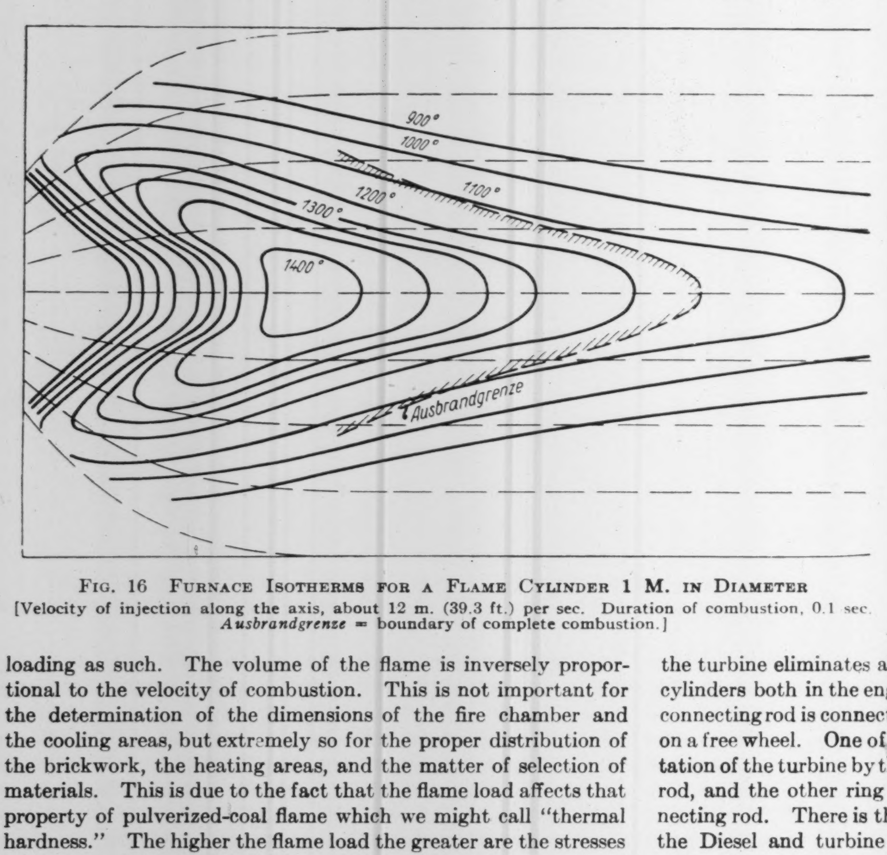

Fig. 16 Furnace Isotherms for a Flame Cylinder 1 M. in Diameter
[Velocity of injection along the axis, about 12 m. (39.3 ft.) per sec. Duration of combustion, 0.1 sec. *Ausbrandgrenze* = boundary of complete combustion.]

Rapid rise of temperature is followed by a slow cooling which is characteristic of all exothermal surface reactions. The further the combustion proceeds the further are the isotherms extended in the axial direction, which means that the laws of radiation practically govern the graph.

The author claims that this astounding agreement between calculation and experience is of very great value, inasmuch as it affords the possibility of predetermining in advance the action of a flame, and is of valuable assistance to the designer in laying out his firing plant.

The article is followed by three appendixes. In the first, a general determination of the flame, the author considers the powdered-coal flame as a suspension of burning particles of pulverized coal in the air and gases of combustion. It is therefore a burning core and not a gas medium which is the starting point for all radiation and combustion phenomena.

The second appendix is devoted to the development of the fundamental theory of dynamic thermal equilibrium and its application to the problems of: (*a*) heat transfer to the heating areas in the furnace; (*b*) development of heat in the firing chamber; and (*c*) conditions of equilibrium.

The third appendix deals with the coefficient of radiation in the case of solids and gases, as well as with the matter of transparency to radiation. (P. Rosin and R. Fehling in a paper presented on May 22, 1930, to the Pulverized Coal Board of the Federal Coal Council, at a joint meeting of the Committee of Investigation of Combustion Problems of the Federal Coal Council and the Subcommittee on Boiler Firing of the German Society of Engineers; read before latter body in Dresden, Nov. 14, 1930, and abstracted through *Die Wärme*, vol. 54, no. 3, Jan. 17, 1931, pp. 42–50, 15 figs., *eA*)

International Congress of General Mechanics, Liege, 1930

A Heavy-Oil Gas Turbine

THE heavy-oil gas turbine described in a paper read by M. Brasseur at the Congress is a combination of a two-stroke-cycle double-acting Diesel engine and a turbine with three velocity stages. The groups of two cylinders in the Diesel are remarkable in that they have a single connecting rod with two pistons located at the ends of the connecting rod and without any connection to the turbine disk. A single reciprocating movement of the straight-line connecting rod running in two guides insures the different phases of the Diesel cycle for each group of two cylinders located along the same axis. This connecting rod carries with it the connecting rods of a four-cycle compressor providing injection air and air for starting. The absence of connection between the engine pistons and the turbine eliminates all lateral thrust of the pistons against the cylinders both in the engines and in the compressors. The engine connecting rod is connected to the turbine by a double ring mounted on a free wheel. One of these rings is carried in the direction of rotation of the turbine by the right-hand side of the engine connecting rod, and the other ring by the left-hand side of the engine connecting rod. There is therefore a complete independence between the Diesel and turbine sides of the installation. The turbine proper is mounted on the engine crankshaft and concentric to the bucket wheel is mounted the ring of turbo-compressors furnishing the scavenging air for the Diesel cylinders. The water pump with two circular radiators provides cooling water for the Diesels and compressors. The Diesel cylinders are set in pairs all around the periphery of the turbine and in such a number as would make it possible to increase the power without modifying in any essential way the turbine parts. As soon as the turbine is started the connecting rods first carry the turbine disk; then as the velocity of the gas increases the connecting rods come into play less and less, and finally act merely as a reservoir to feed hot gas to the turbine. The number of back-and-forth strokes of the engine connecting rod increases until an equilibrium is established between the engine work and the work of resistance consisting chiefly in the compression of the engine cylinders and compressors. (*d*)

INVESTIGATION OF STEAM PIPING FROM THE POINT OF VIEW OF ITS ABILITY TO ABSORB THE EFFECTS OF EXPANSION BY ELASTIC DEFORMATION

It is claimed by its author, Henri Carlier, that the present paper gives a general method for determining the elastic ability of steam piping.

1 Case of a Pipe Rigidly Held at A and B (Fig. 17). The following are the general formulas expressing the elastic ability of the pipe in the two principal directions of the figure or the virtual elastic displacements Ax_B and Ay_B of the end B with respect to A:

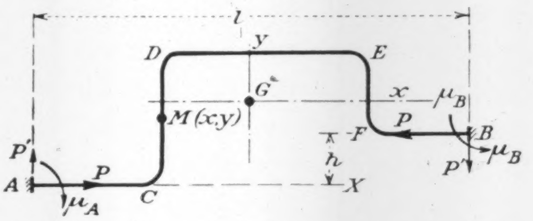

FIG. 17 CASE OF A PIPE RIGIDLY HELD AT BOTH ENDS

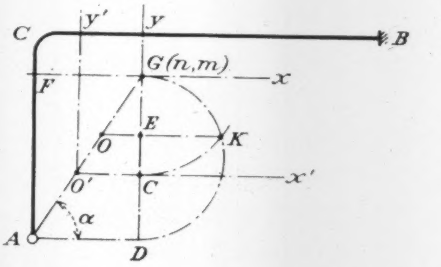

FIG. 18 GEOMETRIC CONSTRUCTION TO DERIVE THE ORIGIN OF AXES x' AND y' IN THE CASE OF A PIPE HELD AT ONE END AND ROTATED AT THE OTHER END

$$\frac{1}{EI}\,(PI_x - P'I_{xy}) = \Delta x_B = l\alpha T$$

$$\frac{1}{EI}\,(P'I_y - PI_{xy}) = \Delta y_B = h\alpha T$$

In Fig. 17, G is the center of gravity of the figure and is here also the central point of the elastic system. G_x and G_y are two axes located parallel to the principal directions of the figure. P and P' are the reactions created by the expansion in the two directions; α is the coefficient of expansion; T, difference of temperature; E, coefficient of elasticity of the metal of the tube; I, moment of inertia of the section of the tube; I_x, moment of inertia of the figure relative to the axis of x; I_y moment of inertia of the figure relative to the axis of y; and I_{xy} = resultant moment of inertia.

2 Case of a Figure Where the End A Undergoes a Rotation α_A While the Other End B Is Rigidly Held. The virtual displacements of the point B with respect to A are expressed by the formulas

$$\frac{1}{EI} = (PI'_x - P'I_{xy}) = \Delta x_B = l\alpha T$$

$$\frac{1}{EI} = (P'I'_y - PI_{xy}) = \Delta\, y_B = h\alpha T$$

The point O' determining the origin of the axis $x'y'$ can be determined by the geometric construction shown in Fig. 18. O is the central point defined by the condition

$$\alpha_A + \int \frac{Mds}{EI} = O$$

The points A, O, O', and G are on the same straight line. This method permits determining the central point on the direction of the central force together with its properties.

Operating Experience With 1200-Lb.-Pressure Boilers at the Masonite Corporation

IN THE Masonite process wood chips are blown into fiber by the use of steam at a pressure of 1000 lb. per sq. in. In this case, therefore, the high-pressure steam is used for process primarily. Two boilers are available, 1200-lb. pressure Babcock & Wilcox make of the cross-drum, sectional-header type. One of these boilers is fired with wood refuse, while the other is fired with coal by a Westinghouse single-retort stoker. By the end of the year both boilers will have been changed to natural-gas firing.

The following operating experiences have not been previously published. The 2-in. tubes have proved to be more immune to failure due to scale formation than have the heavier-wall $3^1/_4$-in. tubes. This is directly due to the thinner wall sections. Another advantage in favor of the thinner tubes is the lower flue-gas temperatures.

Although condensate from the low-pressure drying system is used for boiler-feed purposes, the boiler feed at times contain 4 p.p.m. of hardness expressed as calcium carbonate. This hardness is chargeable entirely to leakage of the [illegible] steam condensers.

The only tube failure to occur in the past seven months was that of a tube in the bottom row of the second high-pressure boiler. This failure occurred on a Tuesday night, but the boiler was kept operating at 250 per cent of rating until the following Sunday morning. This fact has been proof to the operating personnel that the operation of boilers at this pressure is no more dangerous than the operation of boilers in the lower pressure ranges.

The tube failure previously mentioned was caused by the deposition of a dried-out sludge on the bottom of the lower row of the tubes. Since the boilers were opened for an insurance inspection two weeks before the failure occurred, it is apparent that this could not have been prevented. The boiler was left dry during the two weeks that followed the inspection due to the fact that the mill was not running and the boiler room was shut down, making it impossible to pump up the boilers.

From data in the original article it would appear that the failure was caused by sludge deposits, an analysis of which is given in that article. In order to minimize the danger of hard-scale formation in the high-pressure boilers it was decided to maintain a sodium carbonate alkalinity of between 80 and 130 p.p.m. and a phosphate concentration of from 50 to 100 p.p.m. (E. G. Grady, Steam Engr., Masonite Corp., Laurel, Miss., in *Combustion*, vol. 2, no. 7, Jan., 1931, pp. 47–49, 4 figs., *p*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Survey of United States Screw-Thread Practice

UNDER the direction of the Sectional Committee on the Standardization and Unification of Screw Threads, sponsored by the Society of Automotive Engineers and The American Society of Mechanical Engineers, with the National Bureau of Standards cooperating, a comprehensive survey of screw-thread practice in the United States is now being made. Over one hundred and fifty manufacturers and users of threaded products, so chosen that they constitute an average cross-section of industry, are being visited by the Committee's representative. Each firm is being requested to give five samples each of the following twelve (12) sizes: Coarse-thread series 6-32, 10-24, $^{3}/_{8}$-16, $^{1}/_{2}$-13, $^{3}/_{4}$-10, 1-8 and $1^{1}/_{4}$-7; fine-thread series $^{3}/_{8}$-24, $^{7}/_{16}$-20, $^{1}/_{2}$-20, $^{5}/_{8}$-18, and 1-14. Bolts, studs, nuts, and tapped holes, in all about 3000 items, are being forwarded to the Gage Division of the National Bureau of Standards at Washington. Here arrangements have been made for accurate measurement of the various elements of the threads and comparison of these with the American National Standard. The Committee's representative is also obtaining from each firm visited a complete report of its experience with American National Standard Threads and their gaging practice in the form of answers to a questionnaire.

Many individuals, societies, and organizations of various kinds have had a part in the development of the present American National Standard for Screw Threads, which is now very generally recognized by both manufacturers and consumers in this country. It was a long process, beginning with the gradual evolution of the so called "U. S. Standard." In 1907 the A.S.M.E. added the dimensions for machine screws and coarse and fine threads, and in 1911 the S.A.E. completed and published the fine-thread series ($^{1}/_{4}$ in. to $1^{1}/_{2}$ in., inclusive).

The Great War emphasized very forcibly the great need for uniformity in screw-thread practice in the United States, especially in regard to major diameter, pitch diameter, and minor diameter, and the limits for these dimensions in several classes of fits. Accordingly in July, 1918, Congress appointed the National Screw Thread Commission. After three years of intensive work the first report of the Commission was issued in 1921. Industry, as represented by the Sectional Committee on Standardization and Unification of Screw Threads, sponsored by the Society of Automotive Engineers and the American Society of Mechanical Engineers under the procedure of the American Standards Association, made a careful study of this report, and after joint conferences with the N.S.T.C. completed its first report which became an "American Standard" and was published in May, 1924. This standard covers only screw threads for bolts, machine screws, nuts, and commercially tapped holes.

The second and third reports of the Commission were completed and published in 1924 and 1928, respectively. It is the 1928 report which is now before the Sectional Committee for review. The present survey is intended to give authentic information upon which to base this review and the revision of the American Standards for screw threads originally published in 1924.

To assist the staff of the Bureau of Standards in obtaining the necessary measurements on the samples, all the gage manufacturers have loaned on request such gages and other precision instruments as are required with the exception of the "not go" thread plug gages, which are being furnished by the Bureau. Included in the items supplied by the gage manufacturers are the following: roller snap gages, micrometer calipers, thread micrometers, indicating thread gages, "go" thread plug gages, plain taper plug gages, and also optical-projection equipment.

After all samples have been collected and the measurements completed and tabulated at the Bureau of Standards, a report will be prepared by the Sectional Committee giving the findings in detail. This report will not, of course, identify the various cooperating firms with the particular samples which they will have supplied. This information for obvious reasons will be kept entirely within the files of the Bureau of Standards.

From the data obtained the Sectional Committee will be able to judge the extent to which the American National Screw Thread Standard has measured up to commercial requirements, and in what respects revisions should now be made in order that the standard may be made of greater service to American industry.

The expenses for this screw-thread survey are being met jointly by the Bureau of Standards and the Sectional Committee. The Committee's part thereof in turn has been subscribed by Engineering Foundation and a number of manufacturing firms.

I.S.A. Conference in Copenhagen

THE American Standards Association (A.S.A.), as a member body of the International Standards Association (I.S.A.), announces that a conference of secretaries of national standardizing bodies and a series of meetings on technical subjects will be held in Copenhagen, Denmark, early in the present month.

The projects on the program of the technical meetings to be held in Copenhagen are given below, the country named in parenthesis being the secretariat for the project: ISA 20, Aeronautics (*Germany*); ISA 10, Drawings (*Switzerland*); ISA 4, Ball Bearings (*Sweden*); ISA 23, Agricultural Machinery (*Germany*); ISA 7, Rivets (*Holland*); ISA 2a, Metric Screw Threads (*Switzerland*); ISA 2b, Metric Bolts and Nuts (*Switzerland*); ISA 3, Fits Between Cylindrical Parts (*Germany*); ISA 17, Steel and Iron (*Switzerland*).

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of March 15-April 15, 1931:

Cotton Rubber-Lined Fire Hose (Revision of L3-1929). (American Tentative Standard)

Sponsored by the American Society for Testing Materials, Fire Protection Group. Published by the American Society for Testing Materials.

Cast-Iron Pipe Flanges and Flanged Fittings for Maximum Working Saturated-Steam Pressure of 25 lb per Sq. In. (Gage), (B-16b2). (American Tentative Standard)

Sponsored by the Heating and Piping Contractors National Association, the Manufacturers Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers. Published by the A.S.M.E.

Work of A.S.M.E. Boiler Code Committee

Revisions and Addenda to the Boiler Construction Code

THE Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as addenda to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PARS. P-253, L-53, AND U-34. MODIFY REVISION OF PAR. P-253 AS PUBLISHED IN APRIL ISSUE, AND REPLACE PRESENT PARS. L-53 AND U-34 BY THE FOLLOWING:

Rivet and Staybolt Holes. All holes FOR RIVETS OR STAYBOLTS IN PLATES, BUTT STRAPS, HEADS, [in] braces AND lugs [and sheets for rivets or staybolts] shall be drilled; or they may be punched at least $^{1}/_{8}$ in. less than full diameter for material not OVER [more than] $^{5}/_{16}$ in. IN thickNESS and at least $^{1}/_{4}$ in. less than full diameter for material OVER [more than] $^{5}/_{16}$ in. [thick].

Such holes shall not be punched in material more than $^{5}/_{8}$ in. IN thickNESS.

[For finishing the rivet holes, the plates, butt straps, braces, heads, and lugs shall be firmly bolted in position by tack bolts.] For final drilling or reaming THE HOLES to full diameter, THE PARTS SHALL BE FIRMLY BOLTED IN POSITION BY TACK BOLTS.

The finished holes must be true, clean, and concentric.

PAR. P-266. ADD THE FOLLOWING SENTENCE:

THESE OPENINGS SHALL BE NOT LESS THAN 1 IN. PIPE SIZE FITTED WITH BRASS PLUGS.

PAR. P-308. MODIFY PROPOSED REVISION OF SECOND SENTENCE AS PUBLISHED IN APRIL ISSUE TO READ AS FOLLOWS:

NO VALVES SHALL BE SO INSTALLED ON SUCH CONNECTIONS THAT DAMS OR POCKETS CAN EXIST FOR THE COLLECTION OF SEDIMENT IN SUFFICIENT QUANTITIES TO OBSTRUCT FLOW; NOR SHALL ANY VALVES, SUCH AS STRAIGHT-RUN GLOBE VALVES OF THE ORDINARY TYPE AS SHOWN IN FIG. P-23, CONTAINING DAMS OR POCKETS THAT WOULD CAUSE SUCH OBSTRUCTION TO FLOW BE USED [Straight-run globe valves of the ordinary type as shown in Fig. P-23, or valves of such type or so installed that dams or pockets can exist for the collection of sediment in sufficient quantities to obstruct the flow, shall not be used on such connections].

PAR. H-74. MODIFY PROPOSED REVISION OF LAST SENTENCE AS PUBLISHED IN APRIL ISSUE TO READ AS FOLLOWS:

If desired, steel of A lower tensile strength than specified may be used, PROVIDED IT MEETS ALL THE OTHER REQUIREMENTS OF THE CODE SPECIFICATIONS AND the [desired tensile limits to be] specified [with a] range of TENSILE STRENGTH IS 10,000 lb. per sq. in.

M-4*c*. REPLACE THIS SECTION AS PUBLISHED IN APRIL ISSUE BY THE FOLLOWING:

Grade of Welding C. WHEN FUSION-WELDED JOINTS ARE USED THEY SHALL BE MADE IN ACCORDANCE WITH THE REQUIREMENTS OF GRADE A OR GRADE B WELDING AS SPECIFIED IN THE CODE FOR UNFIRED PRESSURE VESSELS, AND THE MAXIMUM ALLOWABLE WORKING STRESS AT RIGHT ANGLES TO THE DIRECTION OF THE JOINT SHALL BE IN ACCORDANCE WITH THE GRADE OF WELDING USED.

Table Proposed for Incorporation in Power Boiler and Unfired Pressure Vessel Sections:

TABLE...

ALLOWABLE WORKING STRESSES FOR 100 PER CENT EFFICIENCY AT VARIOUS TEMPERATURES FOR FIVE GRADES OF A.S.M.E. BOILER CODE PLAIN CARBON STEEL FOR WHICH THE MINIMUM TENSILE STRENGTH OF THE SPECIFIED RANGE IS AS GIVEN IN THE TABLE

Temp. Deg. Fahr.	Minimum Tensile Strength, Lb. per Sq. In.				
	45,000	50,000	55,000	60,000	75,000
60–730	9000	10,000	11,000	12,000	15,000
750	8220	9,110	10,000	11,200	13,000
800	6550	7,330	8,000	9,000	10,200
850	5440	6,050	6,750	7,400	8,300
900	4330	4,830	5,500	5,600	6,000
950	3200	3,600	4,000	4,000	4,000

This table applies to all plain carbon steels for which specifications are given in the Code. Where the minimum tensile strength of the specified range differs from those for which values are given in the Table, the working stresses for such materials may be determined by interpolation.

Approval of Boiler and Pressure-Vessel Design

DURING the past year the Boiler Code Committee of the A.S.M.E. has received a considerable number of requests for approval of designs or details of construction of boilers or pressure vessels—so many, in fact, as to indicate a possible general misunderstanding of the real function of this Committee and the part it plays in the field of boiler construction. The Committee therefore authorizes the following statement in order to outline clearly the responsibility with which it is charged in the hope of obtaining fuller and more complete cooperation in its work.

The Boiler Code Committee was appointed to establish rules for the construction of safe boilers and pressure vessels, and to interpret and revise the rules as the needs of industry might require. The Society gave it no authority to pass judgment on the relative merits of particular designs. This was the result of constitutional restriction against any activity of a commercial character, or any recognition or endorsement of a commercial product by the Society. The Committee has endeavored to keep well within the scope of its appointment, and therefore has avoided taking any action that might have been construed as an approval of a specific design or construction.

The Boiler Code Committee will state, upon request, whether any particular feature of a design or construction does or does not conflict with the Code. Questions other than those regarding particular features of designs should be taken up with the state or municipal inspectors having jurisdiction or with the National Board of Boiler and Pressure Vessel Inspectors,[1] the membership of which is composed of representatives from the states and municipalities that have adopted the Code.

The Boiler Code Committee is, of course, always ready to reply to inquiries about the specific application of the rules in the several sections of the Code, and will endeavor to interpret them to the best of its ability whenever the need arises. Inquirers are requested to be specific concerning the actual rule in the Code upon which explanation is desired. In all cases, requests for approval of a design or construction should be avoided in communicating with the Committee, and pains should be taken to state the bearing of the matter in question on the Code.

Occasionally, manufacturers evolve designs or details of construction for which no rules are found in the Code and in some cases have asked the Boiler Code Committee for guidance. It is the practice of the Committee in some such cases to call attention to the provisions in the revised rules for the testing of a full-sized sample either to destruction or to the elastic limit (in the latter case the pressure part or vessel is not rendered unfit for service). A report of the test, if certified to by some one authorized by the Boiler Code Committee to witness the test, may be forwarded to the Boiler Code Committee for an expression of opinion as to the safe working pressure of the part or vessel tested. The procedure for this form of testing is outlined in the Standard Practice for Making Hydrostatic Test on a Pressure Part to Determine the Maximum Allowable Working Pressure which is given in the addenda to the Appendix (issued on August 12, 1930). A clear understanding of this procedure will obviate misunderstanding and save delays. (See Pars. P-247 or U-51 of the Code as recently revised, or pink addenda pages issued August 12, 1930.)

Correspondence

Low-Cost Peak-Load Capacity With Bleeder Turbines

TO THE EDITOR:

The problem of supplying peak-load capacity at small cost is one of the important factors in any considered scheme of power-station running, and proposals which show promise of financial advantages should be closely examined by all engineers. Professor Christie and Mr. Viessman are to be congratulated upon the clear and concise manner in which they have dealt in their paper[2] with the particular aspect of combining the advantages of stage feed heaters and accumulators in order to meet peak loads of short duration.

Questions relating to feed heating are of particular interest to engineers in this district, since their use in stages was advocated by Mr. James Weir, of Glasgow, about 40 years ago. The firm with which he was associated was specially interested in marine work, and its proposals included the provision of heaters supplied with steam from the receivers of compound and triple-expansion reciprocating engines. While some few ships were thus fitted, the system never became popular, and it was left to the station engineer on land to recognize the thermal and practical advantages that his application of the "Stirling" cycle would give him.

The proposal of the authors commends itself in various ways, but chiefly by its combination of simplicity with efficiency. It would appear indeed that the system should find favor wherever peak loads of from two to three hours have to be met. At one extreme of the proposed system the overload is met entirely by cutting off the feed heaters, using no hot-water accumulators, and forcing the boilers to supply the necessary feed heat. At the other extreme of the system the overload is met by cutting off the feedwater heaters, using hot-water accumulators capable of supplying the fully heated steam, and putting no extra load on the boilers.

There are two ways in which these extreme cases can be bridged. In one case the given plant is to operate with a reduced number of heaters and therefore a lower feed temperature at the boilers. The results of this are a lower accumulator operating pressure, no extra load on the boilers but a decided reduction in peak-load capacity. In the other case the full number of heaters is retained, but the accumulators are placed after such a heater so as to secure a certain lower operating pressure. When overload occurs all the heaters are cut off and the boilers forced to a greater or lesser extent, depending upon the position of the accumulators.

The second method has much in its favor, since the overload capacity is almost fully retained. It remains, therefore, to obtain the necessary cost per kilowatt of each combination possible.

In connection with both schemes it is well to note that for each separate turbine and boiler plant there is a certain number of feed-heating stages which will be thermodynamically the most efficient. Hence the conclusions reached with one plan may not be quite applicable to another.

A point which might be considered is the effect of the various changes proposed upon condenser performance. As each feed heater is cut out of the circuit an increased duty will be put upon the vacuum-producing apparatus. Also the overload and heating value of the bled steam varies with its stage pressure; i.e., one pound of steam extracted at 80 lb. will give more work and supply more feed heat than one pound extracted at 20 lb. Consequently the extra steam to be condensed is not just proportional to the overload obtainable with any given arrangement.

The writer has read the paper with great interest. He appreciates the vast amount of calculation that has been expended upon the production of the simple curves offered by the authors and would like to indicate that the success they have attained in making so lucid a presentation of their case should not hide the fact that they have put into its preparation a very great deal of hard work.

A. L. MELLANBY.[3]

TO THE EDITOR:

The scheme for obtaining low-cost peak-load capacity with bleeder turbines as proposed by Mr. Viessman and Professor Christie has many attractive features. The writer would like, however, to point out a few factors which should not be overlooked.

1 The feedwater temperatures chosen are somewhat high, and beyond those which are at present considered good practice. Using the figures which are now considered good practice, the increase in capacity which could be obtained on both 400-lb. and 1200-lb. installations will range from 12 to 14 per cent.

2 The amount of energy which can be stored in accumulators by this system is, so far as the writer can see, practically equal

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[1] Inquiries which are taken up with the National Board of Boiler and Pressure Vessel Inspectors should be addressed in care of the Secretary, Mr. C. O. Myers, 145 North High Street, Columbus, Ohio.

[2] MECHANICAL ENGINEERING, February, 1931, p. 111.

[3] Professor of Mechanics and Mechanical Engineering, Royal Technical College, Glasgow, Scotland. Mem. A.S.M.E.

to that which can be stored in the usual Ruths system for the same volume, excepting that a very decided advantage is obtained in using existing station equipment to develop the power.

3 This same system has been in use at the Mannheim Municipal Power Plant under the direction of Dr. Maguerre for some two years' time.

G. B. Warren.[4]

Flexibility Pays

To the Editor:

A manufacturing practice which is not unusual is that of providing equipment for the largest units in process, regardless of their prominence from a sales-volume viewpoint. This results in creating an excessively high labor cost on the smaller units, which many times are the ones that are sold in the larger quantities.

As an example of what is meant, the writer will cite an instance where two tanks were used for a dipping operation on articles which ranged in size from 2 in. to 6 in. at 1-in. intervals. Each tank had a "built-in" rack which could accommodate twelve of the 2-in. articles or six of the 6-in. articles. By providing five quickly interchangeable racks for each tank the following was accomplished:

Size of unit in process	Per cent of total sales	Number of units per immersion		Direct labor saving, per cent
		With old racks	With new racks	
6 in.	4	6	6	0
5 in.	6	10	14	40
4 in.	70	12	20	67
3 in.	10	12	22	83
2 in.	10	12	24	100
Total	100			68

Within a few months it became necessary to dismantle one tank and to eliminate the habitual overtime, because of the fact that the potential capacity of a single tank was being utilized more completely. Maintenance and operating costs were reduced 50 per cent thereby.

A careful diagnosis of conditions and equipment with a view to modification, where logical, may often provide the answer to a demand for more capacity or lower costs.

G. W. Isbell.[5]

Tension Tests

To the Editor:

Bulletin No. 210, dated June 24, 1930, of the University of Illinois Engineering Experiment Station, provides test results of the greatest value, not only as regards the strength of rivetr in tension but also regarding tension tests in general.

The results comprise tension tests on rivets $^3/_4$ in. in diameter and in many cases with a grip length of only 2 in. In the test results small pieces of plate are shown riveted together and measurements are given of load against the corresponding longitudinal extension along the axis of the rivets.

It will not be out of place to draw attention to a very simple effect which appears to be often overlooked. This is that in tensile tests when the load is applied to the skin of a test piece, part of the load is transmitted to the center by means of shear force, and as no material is perfectly rigid, the longitudinal fibers at the center will stretch less than the skin fibers.

Taking, for example, $^{13}/_{16}$-in.-diameter cold-driven rivets of 2 in. grip length, the results show that in some cases the center fibers do not begin to stretch until a considerable load has been applied. In another case the center fibers begin to stretch in compliance with the modulus of elasticity of the material as soon as the load is applied.

Contrary to the conclusion arrived at in the Bulletin, it is suggested that the explanation of this apparent contradiction is that in the first case the rivet at the commencement of test has no appreciable longitudinal stress over its whole cross-section. But in the second case the skin is probably at an initial plastic strain corresponding to a longitudinal stress of about 13,000 lb. per sq. in., possibly due to the wedge action which would be produced if the edges of a rivet head were pushed in by holding an air hammer inclined to the axis of a rivet, and running the hammer around the circumference to clean up the edges of the rivet head.

If this shear effect (which depends to a great extent upon the ratio of diameter to grip length) is true, it is not surprising that tensile tests on standard cement briquets do not yield the true value of the tensile strength of portland cement.

Further, this effect probably has a profound influence on the correct interpretation of tensile-test results on cast iron, because when a short, thick specimen of cast iron is pulled it is likely that, owing to shear deformation, the center fibers are hardly stressed at all. It is usual to explain the apparent low tensile strength of short, thick cast-iron specimens by saying that the material at the center of the casting has a lower tensile value than that at the skin. While this is undoubtedly true, the shear effect nevertheless probably exerts a preponderating influence.

In the case of mild steel (which becomes plastic at high stress) the effect is concealed for two reasons: (1) that usually the ratio of diameter or breadth of specimen to the grip length is small, and (2) even if short, thick specimens are pulled, the stress at the center may be, say, 14 tons per sq. in. while the skin stress is 20 tons per sq. in.; but owing to the remarkable plastic properties of mild steel the skin stress can remain at about 20 tons per sq. in. while the center stress builds up to the same value. In this connection it will be remembered that mild steel stretches rather less than one-fifth of 1 per cent of its length when the stress is raised from zero to 20 tons per sq. in., while in the neighborhood of 20 tons per sq. in. the plastic yield of mild steel amounts to approximately 2 per cent of its length.

If shear effect really has the large influence attributed to it above, its exhaustive testing would prove of considerable value. The effect could be verified in actual tests by keeping grips and the test cross-section constant while varying the overall length of specimens of "brittle" materials such as cast iron or cement.

A. C. Vivian.[6]

[Commenting on Mr. Vivian's communication, W. M. Wilson, research professor of structural engineering, University of Illinois, writes that he believes the interpretation given in the Bulletin (that the difference in the strain at low loads among various cold-driven rivets is due to a difference in the initial stress in those rivets) to be more logical than the explanation offered by Mr. Vivian (that the difference is due to a difference in the longitudinal skin stress). However, this would not preclude the use of the tests cited as an introduction to Mr. Vivian's main theme, the effect of skin stress upon the apparent strength of brittle materials, and such tests as he suggests would be desirable in case they have not already been made.—Editor.]

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MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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Accident Prevention in Times of Depression

OUT of the gloom of the period of depression from which we are believed to be just emerging today, the National Safety Council has managed to extract a pleasing item of news showing the changed attitude of industrial management toward accident-prevention activities.

"Safety engineers," the Council says, "have been retained in their positions during this long and severe depression, whereas in 1921 they were laid off right and left. We know of only one safety man being laid off last year, and he had no trouble in securing another position at once. All this means that the Management now recognizes the value of accident-prevention work and is according it its rightful place as an essential item of good management, and therefore looks upon the safety man as one of the 'key' men to be retained.

"The depression has also afforded an unusual opportunity to the plant safety man to attack the human-element problem—to make 'set-ups' for selectivity of men and for intensive systematic educational work and for 'job training.'"

The Right to Drive

USEFUL and important inventions like matches, explosives, and the automobile have brought incalculable benefits to mankind, but have also been the source of much trouble and destruction. Fires, wars, and fatal accidents have been ghastly and costly reminders that we must usually accept the bitter with the sweet, and view every material blessing that results from the ingenuity of inventive minds as a potential scourge if strict and adequate precautions are not taken with as much intelligent foresight as muddling humans may have. To keep our greatest blessings from becoming destructive nuisances requires eternal vigilance and much regulation.

Writing in the *Atlantic Monthly* on "The Right to Drive," Prof. R. S. Kirby calls attention to the fact that "to date in the United States alone more than a quarter of a million people have been killed by or in automobiles," and that "American automobiles are responsible each year for direct property damage of 200 millions of dollars." Professor Kirby further demonstrates that "most of the casualties for which the driver is to blame are due to a lack on his part of at least one of the three qualities of concentration, caution, and consideration."

With the conclusion that a reduction in automobile accidents will come "through a process of thoughtful selection and education of drivers, uniformly enforced discipline, and careful and constant elimination of the relatively small number who prove unfit," we are in hearty accord. Engineers have improved road and traffic conditions, and have made automobiles more readily controllable—factors that have, in themselves, greatly reduced the possibilities of accidents. They should also add the weight of their influence as intelligent citizens in backing up motor-vehicle commissioners who honestly attempt to restrict the "right to drive" to those who are truly competent to drive.

Do Things Last Too Long?

IN MANY lines of manufacturing the replacement business pays as well as, if not better than, the initial business. In the old days kerosene lamps were given away in China and the Far East generally, with the idea that the people who might not invest in the lamp would buy kerosene after having secured a lamp free. Other similar examples readily come to mind.

From this point of view the question arises whether we are not coming to a state of affairs where things last so long that the replacement and parts business is becoming affected. It has been estimated that in the United States from 15,000,000 to 20,000,000 tons of steel are destroyed by rust every year. The steel production of the country therefore has to take care of two items: one, replacement of structures as destroyed, and the other, new construction due to the growing population and constantly increasing industrialization of the country. It is a terrible waste to have so much steel destroyed, and we are gradually developing methods of prevention and reduction of corrosion, the peak of these efforts being represented by high-chromium non-rusting steels of various kinds. Today these steels are still too expensive for general use, but suppose that a cheap steel endowed with non-rusting properties is developed. The result will be that in a few years the production of the steel mills will be cut in half.

Automobile-tire manufacturers today are suffering from having succeeded too well in improving the quality of their product. The automobile owner and the public generally are benefited thereby. Stockholders of tire companies, however, seem less cheerful.

Statistics are available showing that locomotives are operated now with much less maintenance expense than ever before. This is due in part to better materials and better construction, but still more to better methods of handling the locomotives, and the parts business of the locomotive-building companies is unfavorably affected thereby. On the other hand, however, as locomotives now last longer and cost less to maintain, more money is available for the purchase of rolling stock, including locomotives, and there is an increasing tendency to buy expensive machinery rather than machinery that costs little but rapidly wears out.

The wearing out of machinery is an important matter affecting general costs of production, depreciation and obsolescence allowances, and interest on original investment, as well as in some instances matters of general policy, such as choosing whether to spend money on maintenance or on replacements.

Here as in many other instances there is an undoubted conflict between two tendencies: one, of making things last as long as possible through improved methods of construction and operation; and the other the restriction on the market which such a procedure imposes.

Too Much?

IT has generally been assumed that all human endeavor is directed toward the increase of production. Even in the richest countries many persons are living below a minimum standard of comfort, while in the less favored nations huge numbers are leading a life of poverty and privation. It has been the general understanding that the only way to combat this admittedly unfortunate situation was by producing more and more, so that there would be enough goods to satisfy every demand.

When in the interest of personal profits the output of goods has been restricted, violent objections have been voiced in parliaments and in the press. History records many instances where restriction in the output of goods proposed in the interest of favored classes has led to revolution. Quite recently when the British government attempted through the Stevenson Act to control the output of rubber, the rubber-consuming countries, among them the United States, objected and threatened reprisals.

Of late, however, the attitude of peoples and governments toward this subject has changed. An impression exists that what we need now is less rather than greater production. The United States Federal Farm Board has been advocating restrictions in the production of wheat and cotton as the only way for these vital industries to become self-supporting. An international association was recently formed for the restriction of the output of copper and succeeded at first in raising the price of that metal nearly two cents a pound, an increase, however, which refused to stay put. A series of conferences have been held in Amsterdam, Paris, and Berlin, with a view to restricting the amounts of sugar that each of the sugar-producing countries should be allowed to export. Here no complete agreement has been arrived at, and already powerful interests, among others some in Cuba itself, are opposing such restriction.

The latest development along the same lines has been the restriction in the output of tin, which only a few years ago was going up in price by leaps and bounds, a fact greatly facilitated by the limited number of locations where that metal is found in commercial quantities. We have named only those restrictive moves of major importance which have come to or are approaching fruition. A number of other similar movements are under consideration, but for one reason or another have not yet taken complete form.

The scheme for restricting oil output, supported by agencies sufficient to cause the passage of laws restricting drilling in several states, is well known. Notwithstanding this, however, more and more oil is shooting up from beneath the ground. Means for preventing the wasteful production of coal is another serious consideration in this country, and still more so in England.

No attempt is made here to discuss the wisdom or justification of these schemes for restricting production. They may, however, become powerful factors in the life of the world, as most of them are undertaken on an international basis, and as such deserve the utmost attention. And the anomaly of hunger and privation in the presence of overproduction continues to demand the careful attention of engineers and economists.

Airplane Landing Speeds

IN THE course of the presentation of his paper on "The Stagger-Decalage Biplane" (appearing elsewhere in this issue), Prof. A. A. Merrill made a highly suggestive remark to the effect that the current idea that the slow landing of airplanes is desirable as a matter of safety is erroneous, and that, on the contrary, airplanes should land at high speeds.

Professor Merrill's argument is that the speed of an airplane should always be so great during the entire process of landing that it and not any gust of wind will control the path of travel of the airplane. In other words, if a thirty-mile wind is blowing on or not far above the landing-field level, the speed of the airplane should be so much greater than thirty miles that the plane could land in the desired direction no matter from what quarter the wind might be blowing.

The ordinary viewpoint, which incidentally was embodied in the specifications for the prize airplane of the Guggenheim competition, is that an airplane should land as slowly as possible, the ideal way being that it should sink gently to the earth like a feather lost by a bird. But if we watch the landing of a feather on a windy day we shall find that while it may land gently, it certainly does not land in any definite direction. However, there is nothing essentially irreconcilable between the generally accepted view and that expressed by Professor Merrill. The common idea is that it is the jarring of the plane when it lands at a very high speed that is the potential source of trouble, such as, for example, injury to the plane if a perfect landing is not made. Even with a perfect landing, though, trouble may occur if the field is not smooth—for example, a wheel may strike a hummock and the plane land on the propeller or turn over completely. Under these conditions the slower the plane lands the safer it is.

Another reason for using the lowest possible landing speed is that the slower the plane lands the shorter its run after landing, and the less chance there is for trouble and accidents. From all of these points of view the autogiro appears desirable, because it can land at practically no ground speed whatever, and can be stopped within a few dozen yards. In recommending landing at high speed Professor Merrill is of course thinking of his own plane, which has the characteristic, according to his paper, of always landing right side up and of being comparatively free from the tendency to tilt over forward. Under these conditions the dangers involved in fast landing are greatly reduced, while its advantages do not appear to be overbalanced by its incident defects.

The matter of landing speed is an extremely important one not only from the point of view of safety but also from that of the cost of flying fields. One of the reasons why we need such huge fields today is to provide sufficient runway for landing. If we can land safely at high speeds we shall be better able to select the place of landing—which we are not today, and hence, even with the comparatively longer runs, will require shorter fields.

Incidentally, here is a question which we shall not attempt to answer. Why is it that on aircraft carriers such as the *Lexington* and *Saratoga*, means have been provided to permit the landing of planes within very short distances, while no like attempt has been made on fields near our large municipalities where land is valued at city-lot prices?

Engineers in Russia

COMMENDABLE common sense marked the decision of the A.I.M.E. to appoint a committee to draw up a statement for the guidance of engineers contemplating service in Soviet Russia, because it was recognized that while every engineer is free to settle this question for himself, he should do so only after he has thoroughly canvassed the facts of the situation. The April issue of *Mining and Metallurgy* contains the complete report of the A.I.M.E. Committee, significant sections of which are reproduced here for the information and guidance of mechanical engineers, who may not have seen the original. In preparing and publishing this report the A.I.M.E. has rendered all engineers a very real service that is gratefully acknowledged.

The "General Observations" that preface the report point out that "the country has a form of government comparable to the most drastic type of martial law as Americans understand that term." Attention is called to the objectives of the Five-Year Plan, and the result in the standard of living that the carrying out of the program has entailed. Excerpts from the remainder of the report follow.

Living Conditions

a Food, generally speaking, is scarce; some, of very poor quality. It is extremely expensive unless bought at Government stores with a Government food card. While conditions are not uniform throughout Russia, in Moscow and Leningrad long lines of people are obliged to stand in front of these stores waiting to enter.

In certain places the Government has opened special stores for foreign employees. Accounts differ as to how satisfactory conditions are in these stores. Undoubtedly these vary in different districts.

The importation of food as a general proposition is forbidden unless it is agreed upon in the employment contract or arranged for by the contractor or the head of a group. Here, again, opinions differ as to whether importation of food is feasible, even if agreed upon. This apparently indicates the advantage of employment of engineers by large American engineering firms or contractors, rather than the taking of independent employment.

b Housing conditions. In cities such as Moscow there is a great shortage of accommodations. In other districts there is said to be no shortage.

c Articles of clothing, shoes, etc., are difficult of purchase, of poor quality and expensive, throughout Russia.

d Other conditions, such as medical attendance, hospitals, etc., vary greatly in different parts of Russia, but nowhere are these facilities said to be good, except possibly those provided by some American contractors or engineering organizations operating on a large job.

Without question, an engineer should not take children into Russia. Most people familiar with conditions there strongly advise against the taking of wives, unless they be strong, healthy, robust individuals, accustomed to discomforts and inclined to enjoy overcoming difficulties and the fighting of adverse conditions.

Legal Status and Personal Safety

a An individual accepting employment under the Soviets must appreciate that he is working for an autocratic government. The United States has no diplomatic relations with Russia, and there is no United States ambassador or consul to whom he can appeal if he feels himself wronged.

Adequate reasons may develop for the breaking of a contract, but still the Government has the arbitrary power to take away passport and food card, and/or prevent the employee from leaving the country. In such case great difficulty may be experienced in subsisting. The engineer may be fined or forced to do menial work in punishment for alleged breaking of his contract.

b Fear is entertained that, if the five-year plan should not eventuate as represented to the people, or if some plant or installation should fail to deliver anticipated results, the Soviets will seek a "scapegoat." If so, who would be more suited to that role than the foreign engineers in charge of that particular piece of work? Many people have been executed or imprisoned as "scapegoats."

Status Upon Return to the U. S.

Engineers contemplating employment in Russia should furthermore consider the following:

What would be the position of a member of the profession upon return to the United States? Has he improved or depreciated his standing and chances of securing a good job in this country upon his return?

Recommendations in the Event of Accepting Service

If he decides that his particular situation is such that he must accept Russian work regardless of the known unfavorable conditions, then he should if possible give preference to employment with some large American contractor or engineering firm, rather than attempt an individual contract with the U.S.S.R.

While the matter of performance of an employment contract by the Soviets is a matter of faith, on account of the impossibility of bringing any dispute before an American court, still as far as we know they have thus far shown a disposition to live up to the *letter of the contract*. This being so, it becomes important that the contract terms should embrace every possible contingency. No dependence whatever should be placed on verbal statements or assurances. It has been found repeatedly that assurances made here have no force whatever when the employee arrives in Russia.

Whether going as an individual or as a member of a group, one should see that the following points, among others, are provided for:

a Adequate provision for first-class transportation and expenses from America to place of employment and return.

b The extent to which payments will be made in dollars in the United States and rubles in Russia. He should insist on receiving as large a portion as possible, certainly not less than 50 per cent of his remuneration, in dollars to be deposited or paid as directed in the United States. It must be remembered that foreign money can be brought out of Russia only to the extent to which it was taken in, less the amount the authorities decide he should have spent while in Russia. After residing in Russia for a certain length of time, no foreign money can be taken out While a certain amount in Russian currency can be sent out, it has only a greatly depreciated value in foreign countries.

c Amount of money the engineer will be required to spend in Russia. Visitors to Russia are required to spend a certain minimum per day, and the engineer should inform himself to what extent these regulations apply in his case.

d A non-resident citizen is subject to our Federal income tax, but should be free from taxation by the Soviet Government on amounts deposited in this country to the citizen's credit. A definite understanding should be had as to the amount of taxes on salaries paid in Russia, as well as on all other taxes.

e Provision of living quarters, domestic servants, water, heating, light, cooking and sanitary arrangements, either free of charge or at a definite price.

f Fuel for heating and cooking, and price thereof.

g Supply of food and privilege of purchasing food, clothing, and other supplies at commissaries established for foreign diplomats and engineers.

h Privilege in regard to taking in and importing into Russia later foodstuffs, clothing, toilet articles, etc., free of duty, coupled with guarantee of arrival.

i Outlining of duties and responsibilities of service to be rendered.

j The conditions under which employees are privileged to resign with safe conduct and expenses back to the United States, etc.

k Discontinuance at one job not to give Soviet the privilege of transference to another.

l Various Soviet industrial organizations, operating through the Amtorg Trading Corporation in New York, engage American engineers and technicians to work in Russia. As there are no relations between the government of the United States and that of the Soviet Union, the signature of the Amtorg for itself as an American corporation should always be obtained to any contract.

Producing Fast-Growing Trees

FEW realize how important trees are to life on our planet. When we think of engineering materials we consider metals primarily. Where plant vegetation is concerned we think chiefly of cereals and cotton, the first because they give us foods and the second because it is an essential element of clothing. Trees provide lumber, but the feeling is that should the supplies of lumber disappear a substitute could be found in metals or synthetic materials. Actually, however, this is not so, and if by some miracle all the trees were to disappear from the earth, humanity would probably not be able to survive.

Trees control all life through two functions. In the first place, as is quite commonly known, they provide a means of restoring oxygen to the atmosphere, Human beings, animals, and particularly bacteria consume tremendous amounts of oxygen, turning it through their life processes into carbon dioxide. Trees and other plants take up this carbon dioxide from the air, retain the carbon, and liberate the oxygen into the atmosphere.

Moreover it is largely because of the existence of trees that rain is possible. The common idea that rain comes about chiefly through the evaporation of water from seas, lakes, and rivers is incorrect for two reasons. In the first place, the evaporation from large bodies of water is small because of the highly saturated condition of the air in immediate contact with the water. In the second place, not enough moisture can reach the interior of a continent from the seashore, and often there are not enough internal bodies of water available to provide sufficient water for rains. Moreover when rain falls it seeps into the ground; then the sun comes out and the top surface of the soil dries out, leaving a wet stratum underneath. If the moisture in this stratum were not removed, sooner or later swamps would develop. This moisture cannot be removed by evaporation since the wet stratum is shielded by the upper dry layer. Hence trees become creators of rain. A large tree on a hot summer day will evaporate through its leaves as much as fifty barrels of water. All of this is drawn from the subsoil by means of the spreading roots of the tree, so that after every rain the water penetrates into the subsoil in huge quantities and is then evaporated back into the atmosphere by the trees. This is one of the reasons why under natural conditions, in the absence of certain prevailing winds, the distribution of rain is quite uniform over large areas, provided these areas are parts of a continent and not in immediate proximity to seas or very large lakes.

Modern industry is faced with an extremely serious problem. It requires tremendous amounts of timber, partly in the form of constructional lumber and still more so in the form of pulp for the manufacture of paper and cellulose products. So great is the demand for wood that the processes of natural growth to supply it are no longer adequate, with the result that we face either a shortage of cellulose and pulp or a depletion of our forest reserves with all of its attendant grave circumstances. One solution seems to be indicated in methods of producing quick-growing trees by hybridization, which, according to a paper by Ralph H. McKee in this issue of MECHANICAL ENGINEERING, promises to produce trees that will yield pulp much earlier and many times faster than any species of trees now known.

Engineering as a Profession

RECENT reading of a Department of Commerce Circular on Mechanical Engineering, prompts a word of commendation of this brief but concise statement of the essential features of this profession and its opportunities. It will be of great service to those who must advise young men as to their careers, because it defines the field and its branches and the professional societies that serve it, comments on employment, salaries, prospects, and such educational features as the schools, their curricula, admission and graduation requirements, degrees, and expenses, and gives a list of 104 institutions with tuition fees and 1928 enrolments in mechanical engineering.

Excellent as this circular is, however, every engineer will hope that those who make use of it will supplement its statistical statements by indicating what further possibilities await the mechanical engineer who has vision and ability. Especially should it be called to the attention of the novitiate that within fifteen years of graduation from college more than two-thirds of the graduates of engineering courses have passed through the stage of technical engineering practice and have become administrators and managers, and that this percentage is likely to increase rather than to decrease. One of two views must be taken of engineering: either that it is a profession through which men pass to some other vocation for which it has been an excellent preparation, or that it is a much broader and more important profession than those who define it generally acknowledge. We adhere to both of these views, the one literal, the other recognizing the true spirit of engineering.

It is doubtful if a man, having once used the engineering methods that are characteristic of technological practices, ever loses the analytical point of view toward whatever problem he may face. Respect for so-called natural laws that comes with wrestling with such concrete problems as those of mechanics fixes the feet firmly on the ground, while the rapid progress of science and invention keeps the mind alert for creative development. Forced always to consider the economics of his ventures, and to perform them not alone but usually in some organized social group, the engineer finds himself always face to face with contemporary life, thereby gaining ability in the handling of affairs and people.

The boys and young men who choose mechanical engineering for a career may spend some time in power plants and factories, they may design and build machinery, they may grapple with the problems of production and transportation. These are important and worthy services rendered to an industrialized civilization. But in doing these tasks that mean more and cheaper goods and greater material comfort in the lives of their fellow-men, and in sensitizing themselves to the subtle human problems of industry, these youths prepare themselves for positions of leadership and constructive usefulness in their maturer years. Such men as they may then become have the intellectual capacity to create and enjoy true culture. Few professions today can provide greater satisfactions.

Plant-Inspection Trips

ONE IMPORTANT feature of meetings of professional engineering societies is the plant-inspection trip. The privileges that are granted to visiting engineers on these occasions are keenly appreciated by a majority of the visitors, and in general they are not abused.

Bringing 20 to 100 men into a crowded shop cannot be done without some interruptions of working schedules, and those who act as guides must be taken from their regular jobs in order to serve the visitors. Plants that act as hosts on such occasions invariably exhibit the greatest degree of hospitality, although in some cases they have had cause to complain of the actions of their guests.

Those responsible for the conduct of inspection trips usually plan them carefully, but it frequently happens that they cannot control the individual actions of the visitors. After many attempts to ascertain in advance as accurately as possible the number of men participating in the inspection trip, there is generally a last-minute group that upsets all calculations. Difficulties immediately develop in providing transportation, and many times it is too late to make arrangements at the plant to care for the larger party. The thoughtless ones who fail to register in advance and thus swell the number in an inspection group to a size that is dangerous and unwieldy, not only place a greater burden upon the guide but make it that much harder for others to get the benefit of explanations that are always difficult to hear in a noisy factory. Greater thoughtfulness on this point will add to the enjoyment and profit derived from these trips.

A greater discourtesy, less often met with and not likely to occur with organizations that hold frequent meetings, is unusual delay in arriving at the plant to be inspected. No excuse can be offered in defense of a party, scheduled to appear in the morning, that shows up late in the afternoon without announcing a change in plans. This actually happened, we are told, and has not encouraged the plant so treated to extend invitations to groups of visitors.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Real Wages in the United States, 1890–1926

REAL WAGES IN THE UNITED STATES, 1890–1926. By Paul H. Douglas. Houghton Mifflin Company (for the Pollak Foundation of Economic Research, Newton, Mass.), Boston, Mass., 1930. Cloth, $5\frac{3}{4} \times 8\frac{1}{2}$ in., 682 pp., 95 charts, 231 tables. $7.50.

THIS is a monumental work which will possess a high value long after the immediate interest of the period in the history of this country to which it immediately refers has passed.

It is significant that the author himself in his preface states, "I am by no means satisfied with the completed result, but I can take some consolation in the fact that it is as good a piece of work as I can do, and that in the effort to make it so, I have not stinted my outlay of time, of energy, or of the material resources which in other respects I could ill afford."

The man who can make such a statement with as good reason as Professor Douglas has in this case is a fortunate man indeed.

The book starts with an investigation of the movement of living costs in the period 1890 to 1926, which period, by the way, applies to the whole work. The increase in the cost of living from 1890 to 1915 for the urban working classes was not as great as in the previous decade, but rose after 1914, reaching a maximum in July, 1920. There was a material fall in the next two years, with a tendency toward partial stabilization thereafter.

Part 2 deals with the movement of wage rates and hours of work during the fifteen years from 1900 to 1914. The real hourly earnings were on an average 6 per cent above the level of the preceding decade. There was a slight fall during the war, and it was not until 1921 that they were much above the 1915 level. During the three succeeding years the index rose, but the average annual gain over the nineties for the whole period was 12 per cent. On the other hand, the length of the standard working week for the same period declined 15 per cent. The statement that the average real hourly earnings declined during the war and immediately thereafter may seem surprising. As a matter of fact, however, hourly money earnings for the same period were 233 per cent above those of the nineties in 1926, and 125 per cent above the 1914 average. This was equivalent to increases in purchasing power of 38 and 30 per cent, respectively.

The movement of the actual money and real annual earnings of employed workers forms the subject of part 3. This deals with the real earnings of employed workmen in all manufacturing industries, as well as with specific groups of manufacturing industries, transportation, public utilities, coal mines, etc.

The portion of part 3 to which particular attention may be called is chapter 16, dealing with the movement of earnings according to the distance of the industry from the consumer. This shows that in the industries which lie farthest from the ultimate consumer the amplitude of the fluctuations through the business cycle is particularly great, with the result that the profits of these industries also tend to fluctuate violently. Since these industries suffer most in periods of depression, they are compelled to lay off more men and cut the wages of those who remain more stringently than do other industries. When business revives the pick-up is also greater in the basic industries.

These considerations apply not only to basic and final industries, but also as between the intermediate industries and the other two groups. The earnings of the workers in these intermediate industries are seen to fluctuate more violently than those in the final industries, but with less amplitude than those in the basic groups. This would seem to be caused by the fact that, during periods of prosperity, the piling up of inventories proceeds at a faster rate than the sale of consumers' goods. This puts a greater strain upon these intermediate industries, which in turn necessitates greater wage advances in order to build up their labor forces. But the very accumulation of these inventories causes the reduction in orders for these intermediate goods to be relatively greater during periods of depression than the reduction the quantity of consumers' goods which are sold. This leads to a greater falling off in the volume of employment and in the earnings of those who remain.

But while there is thus a greater amplitude of fluctuation in earnings the farther back from the consumer one goes, it is less than the relative fluctuation in the prices of these commodities or in the volume of employment.

There are two other facts which should be noted. The first is that the absolute level of wages is higher in the basic industries than in either the intermediate or the final group. In 1899 the average annual earnings of those in the basic group were $459, while the average for the final group was but $415, and for the intermediate group only $357, or 10 and 22 per cent less, respectively, than the average for the basic group. In 1923 the average of the final industries was 7 per cent, and of the intermediate industries 27 per cent, less than that of the basic industries.

The unemployment and the real earnings of the wage-earning class as a whole form the subject of part 4. From this it would appear that the decade of the nineties was characterized by a higher percentage of unemployment than most of the subsequent years. During the years from 1900 to 1914, inclusive, there was a material decrease in the volume of unemployment. From 1916 to 1920 the workers in manufacturing and transportation were on an average 15 per cent above their position of the nineties. In general, labor's position during the war and post-war periods was very good, though labor gained during these periods not so much in established weekly wage rates or even hourly wage rates, but through an increased use of bonuses, less lost time within employment, more overtime, and a greatly reduced volume of unemployment. On the other hand, in depression years when unemployment is taken into account, the position of labor is appreciably worse than when one considers only the earnings of the employed.

It is impossible to summarize in a few paragraphs the contents of a volume of nearly 700 pages replete with statistics. It may be said without exaggeration that to any one interested in the subject of wages and the position of labor in the United States during the first quarter of the present century, Professor Douglas' book is a real mine of pertinent information.—L. C.

Engineering Thermodynamics

PRINCIPLES OF ENGINEERING THERMODYNAMICS, by Paul J. Kiefer and Milton C. Stuart. New York, John Wiley and Sons, 1930. 6 × 9 in., xiv + 545 pp., illus., cloth, $4.50.

REVIEWED BY C. HAROLD BERRY[1]

AN excellent book. Not many decades ago, thermodynamics was a realm of mystery. The physicist was groping his way toward a true interpretation of what seemed a confusion of discordant experimental observations. Recently, however, there has been a significant development in this field, as in other branches of sciences. Thermodynamics has been robbed of its mystery by the painstaking task of clarifying ideas, making the use of words more precise and the use of mathematics more rigorous. Unfortunately, engineering texts have lagged behind in this development, and have retained many incomplete and often essentially incorrect views, with the result that the student has found the subject difficult to grasp. Further, the difference between the right and the wrong seems to some engineers largely to involve matters of minor concern, and those who strive for exactness are accused of quibbling. This charge is one that any lover of truth is glad to face in his efforts to contribute to the growth of a discriminating appreciation of the experimental basis of science, and to the critical understanding of the mathematical structure built upon it.

This task has been boldly undertaken by Professors Kiefer and Stuart in this book. Their presentation should go far toward dispelling the false ideas that seem to be the portion of many young engineers.

The general course of reasoning of this book is in accord with the basic mathematical theory. The book is not mathematically developed—no more so than several recent texts for engineers; the difference is that the basic concepts are defined with an eye to all aspects of their significance, and that the mathematical steps are correct in notation and argument.

For example, many books have presented the heat transferred to a given body during the change of state 12 in the form $\int_1^2 dq = \Delta q_{12} = q_2 - q_1$, which implies the existence of a function q (of the variables that determine the state of the body), whose differential is exact and integrable in general between any two states. This is not at all the case. There is no function q. This symbol denotes the quantity of heat transferred during a change of state—all of it. Its value depends upon the path of the change of state. For a reversible process it is the line integral along the given path from state 1 to state 2 of an inexact linear differential expression which may be designated as $d'q$ or Dq, but certainly not as dq. The authors present this whole aspect of the Energy Law in a manner that should be at once clear to the student and satisfactory to the mathematical physicist.

In their efforts to encourage a strict delimitation of the meaning of the word "heat," the authors have adopted the name "enthalpy" for the quantity known to the engineer as "total heat" or "heat content." This acceptance of the name "enthalpy" that has long been familiar to the readers of the literature of mathematical physics and physical chemistry is a praiseworthy step in the progress of engineering teaching in respect of both exactness and simplicity. The quantity has no more to do with heat transfer than with work transfer, and its name should imply no such special dependence.

In the presentation of the Second Law and the concept of the entropy of a body, one finds ample room for sincere differences of opinion as to the best approach for a beginner.

In this book the change in the entropy of a given body during a given change of state is defined as a measure of the portion of the heat transferred to the body during the specified change of state that is unavailable with reference to a cyclic operation in which heat is rejected at an assumed constant lower temperature. The discussion of the matter from this point of view will doubtless be received with pleasure by many readers.

The present writer is among those who prefer a more fundamental approach, even for the beginner, but he wishes to make it clear that he is not contending that the authors' point of view is incorrect.

It seems to him unwise to develop the entropy concept primarily in terms of a heat transfer in which the body has never participated, together with a remote temperature that the body may never have approached. The entropy of a body is indisputably one factor of the minimum quantity of energy that must unavoidably be rejected as heat at the lowest attainable temperature of the surroundings during any cyclic operation in which work is continuously or repeatedly developed, and a good case can be made for the contention that this is its most significant aspect for the engineer. But yet it seems clear that this is a secondary derived characteristic. Basically, the entropy of a body is a single-valued continuous function (of the variables that determine the state of the body) whose existence is proved mathematically and whose definition is established with reference to the element of heat transfer actually executed by the body accompanying a reversible change of its state, together with the concurrent value of the actual absolute temperature of the body.

In a footnote, the authors remark that this definition is unfortunate and inadequate, and hence of questionable validity. This view the present writer protests vigorously. The basic definition is not to be questioned. That it does not apply for other than reversible paths does not in the least reduce its applicability, and no amount of consideration of other aspects of the quantity can alter its basic nature. It is defined with reference to reversible paths simply because these are the only paths for which mathematical analysis of any sort is possible, and the definition is necessarily in terms of $d'q/T$ because, before the definition can be established, it must be proved that this differential expression is exact. Lacking this proof, one has no right to define a quantity, for there is no certainty that such a quantity has "existence" in the mathematical sense, that is, no certainty that the definition will lead to intelligible mathematical consequences.

One is somewhat startled by a paragraph heading, "The entropy of energy." This seems to be a bit misleading. The entropy of a body is one of the characteristics of the body, not of its energy. As well speak of the pressure or the temperature of the energy. Energy is not an independent entity whose properties can be enumerated. The energy of a body is a function of the variables that determine the state of the body, and its existence is established by a definite mathematical argument. It is as much an abstraction as is the entropy of the body.

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Having completed the theoretical basis of the subject, the authors proceed to its application to the solution of engineering problems. Their first step is an excellent presentation of the properties and changes of state of vapors and gases. Especially commendable is the extended discussion of changes of state of mixtures of gases and vapors. Part IV of the volume is devoted to a thorough presentation of the thermodynamic aspects of nozzle and orifice flow, prime movers, compressors, blowers, and refrigerating machines. Attention is given to the latest developments in power-engineering practice, and care is taken to make the various analyses complete and exact.

A final chapter presents a brief development of the differential equations arising from the detailed mathematical theory. These occupy so important a place in the advancement of thermodynamic research and in the development of new applications that this concise chapter should prove invaluable as a source of reference for the worker who is beset with a problem in untrodden fields.

As a text for a high-grade course in engineering thermodynamics, this volume can safely be recommended as dependable and clear. As a reference book for the engineer who wants to check up on his grasp of the subject it should prove very useful and thoroughly reliable. It is not easy reading; there is no royal road. But it is a clear, well-planned, safe road whereby the intelligent reader should achieve a sound command of modern scientific thought underlying this important field of mechanical engineering.

A Pulverized-Coal Bibliography

REVIEWED BY WALTER J. WOHLENBERG[2]

TWENTY-THIRD REPORT OF THE PULVERIZED COAL DIVISION OF THE REICHSKOHLENRAT. Berlin, V.D.I. Verlag. Price 6 marks.

DR. O. KNABNER has done a service to the engineer interested in the field of pulverized coal by bringing under one cover, entitled as above indicated, a complete index to the published literature on this subject.

Apparently no effort has been made to separate the wheat from the chaff. Indeed, in the preface Dr. Knabner states that any such attempt may be dangerous in that what is not important from one point of view may prove so from another. Therefore an effort has been made to include references to all publications in this field.

In collecting the material, the files of more than five hundred engineering periodicals and transactions of engineering and scientific societies have been consulted.

The material as a whole is well arranged, being grouped in twenty-three subdivisions, such as

A Fuels
B Driers
C Mills; Grinding, Fineness, etc.
D Combustion Chambers
E Construction Materials
F Burners and Auxiliaries Therefor
G Combustion
Etc.

In each subdivision the articles are filed alphabetically by authors. Under each name appears a list of all the papers published by this author, together with data for identification of the publications in which the papers appeared.

Thus the Twenty-third Report, in addition to being a guide to the literature, might serve as a sort of "Who's Who" in this field of endeavor. No engineer interested in this field can afford to be without it.

A Handbook of Crane Information

CRANE ENGINEERING. Compiled by M. F. Beetham. Whiting Corporation, Harvey, Ill., 1930. Fabrikoid, 5 × 7³/₄, 150 pp., illus., $2.

THIS book is of a practical nature and begins by a section telling how to select a crane. Among other things, it indicates what dimensions are necessary for quoting a price on a crane, and also the dimensions which have to be considered in selecting it. This is followed by a series of tables giving crane clearances.

The author describes in some detail the various types of cranes and indicates their duties. A section of the book is devoted to runway design and to the construction of crane bridges and their details such as wheels, drives, brakes, etc. Crane trolleys are described in considerable detail, and a colored view of the hoisting gear train is included showing the lubrication conditions resulting from the pumping action of herringbone gears.

In addition to the overhead traveling crane, the author deals with several other types, such as bucket-handling cranes, gantry cranes, hand-power traveling cranes, and jib, pillar, and bracket cranes, as well as lifting magnets.

The publication is not a textbook, but one of those home publications by industrial companies which contain a large amount of interesting and apparently reliable information on the subjects to which they are devoted, and which are particularly important in the case of cranes, on which detailed published information in the form of books or trade-paper articles is by no means plentiful.—L. C.

Books Received in the Library

AMERICAN DIESEL ENGINES. By L. H. Morrison. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 606 pp., illus., diagrams, tables, $5.

This book will interest the prospective purchaser and the operating engineer. The author discusses the comparative costs of Diesel and steam plants, the operation and adjustment of Diesel engines, and their suitability for various kinds of work. He also gives descriptions of all the engines that are being made at present in this country, and also of their important parts.

ANALYTICAL CALCULATION OF COMPLICATED AIR-DUCT. By P. N. Kamenev. Stalino (Donbass) Ukraine S.S.R., 1930. Paper, 8 × 12 in., 54 pp., tables, diagrams, $1.

A criticism of the methods proposed by Rietschel and Blaess for calculating the size of air ducts. The author outlines new methods for which greater accuracy and ease of use are claimed. A summary of a more extensive book published in the Russian language.

APPLICATIONS OF INTERFEROMETRY. By W. Ewart Williams. E. P. Dutton & Co., New York, 1930. Cloth, 4 × 7 in., 104 pp. $0.85.

This little book provides a useful description of the various types of interferometers and explains the principles of each type. The scientific and technical applications of interference methods are pointed out, and useful lists of references are given. The work is a useful introduction to the subject for engineers and physicists.

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Aviation. By Bradley Jones. John Wiley & Sons, New York. 1931. Cloth, 5 × 8 in., 314 pp., illus., diagrams, $2.75.

A brief textbook, intended to give the aviator a practical knowledge of the subject. The instruments used, methods of computing distance and track, drift correction, standard and short methods for finding position by astronomic methods, radio navigation, and fog flying are discussed.

Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of All Integer Numbers Up to 10,000. Third edition, edited by L. J. Comrie. E. & F. N. Spon, London, 1930. Cloth, 6 × 9 in., 7s., 6d. 208 pp.

For ninety years Barlow's Tables have been printed from the plates prepared for De Morgan's edition of 1840. The present edition, however, is reset from modern type, and advantage has been taken of the opportunity to restore certain tables that were omitted from the second edition, add some valuable new ones, and effect certain other improvements.

In addition to the values described in the title, the tables give the factorials of numbers up to 100, the fourth powers and the reciprocals of the square roots of numbers up to 1000, and powers to the tenth of numbers up to 100, and up to the twentieth of numbers up to ten. A column giving the value of the square root of every tenth number between 10,000 and 100,000 has also been added.

Bibliography of Aeronautics. By National Advisory Committee for Aeronautics. Government Printing Office, Washington, D. C., 1929. Cloth, 7 × 10 in., 242 pp., $0.35.

This bibliography is the current addition to the series begun by the Smithsonian Institution in 1909 and covers the literature of the subject for the calendar year. Articles are entered under subject and author, without annotations. These bibliographies are quite exhaustive and are indispensable to students of aeronautics.

Les Chaudières a Vapeur. Second edition. By Charles De Bie. Dunod, Paris, 1931. Cloth, 7 × 10 in., diagrams, illus., 174.30 francs.

After a discussion of the properties of fuels and steam, of combustion, of various types of grates and furnaces, and of furnace draft, the author takes up the different models of boilers, economizers, superheaters, and safety valves. The design and construction of boilers is then discussed fully, in the light of the French regulations and laws. Finally, data are given on water purification, boiler-control apparatus, boiler testing, etc. The author is engineer of an important French boiler works.

Chemistry of Engineering Materials. By Robert B. Leighou. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 8 in., 684 pp., illus., diagrams, $4.50.

An elementary textbook upon the chemical properties of the materials used in building and manufacturing, written for users of them rather than for the makers. Water, fuels, metals, foundry sands, building stones, cements, clay products, paints, lubricants, etc., are treated. The new edition has been carefully revised and brought up to date.

Davison's Silk and Rayon Trades. By Davison Publishing Co., N. Y., 1931. Cloth, 5 × 8 in., 660 pp., maps, illus., $5.

A convenient directory of manufacturers, dyers, finishers, importers, dealers, etc. The location of each manufactory is given, with its officers, capacity, and products. The directory has classified indexes as well.

Designing Heating and Ventilating Systems. By Charles A. Fuller. Third edition. Scientific Book Corporation, New York, 1931. Fabrikoid, 6 × 9 in., 244 pp., illus., diagrams, tables, $3.

This book presents a detailed explanation of the methods in general use by designers. The subject is discussed simply and practically, with the employment of a minimum of mathematics. The book is therefore usable by those without extensive technical training.

Economic Control of Engineering and Manufacturing. By Frank L. Eidmann. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 402 pp., illus. diagrams, tables. $4.

Points out problems of engineering and manufacturing which must be solved by economic analysis, and presents methods of procedure for their solution. Among the matters discussed are the choice between different types of equipment, the determination of the economy of proposed changes in equipment, processes, or methods, the proper amount of materials to keep in stock, the economic effects of artificial illumination, and, finally, similar problems.

Entstehung, Veredlung und Verwertung der Kohle. Edited by K. A. Redlich and others. Gebrüder Borntraeger, Berlin, 1930. Paper, 7 × 10 in., 359 pp., illus. diagrams, tables. 30 r.m.

Contains nine lectures by professors and mine operators delivered at a conference held in May, 1929, at the German Technical High School at Prague. These lectures, addressed to graduate engineers, discuss various important problems related to coal mining and utilization, such as the chemical structure and origin of coal, the drying and distillation of lignite, the synthesis of organic compounds from coal gas, the combustion of solid fuels, pulverized fuel, and theoretical principles of mechanical regulation of firing.

Harvard Business Reports, vol. 9; Cases on Industrial Marketing. Edited by Melvin Thomas Copeland. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 363 pp. $5.

Forty-six cases are here reported, discussing a wide variety of actual problems in marketing industrial goods. Professor Copeland contributes a lengthy introduction to the subject and comments on each case.

Illuminating Engineering Equipment, Theory, and Design. By L. B. W. Jolley, J. M. Waldram, and G. H. Wilson. John Wiley & Sons, New York, 1931. Cloth, 6 × 10 in., 709 pp., illus., diagrams, tables, $12.

Starting with an account of the fundamental principles of illumination, the authors next describe the varieties of electric lamps used as sources of light, and then take up the question of lighting equipment. This topic is the major one of the book and is treated at length. The types of equipment for various purposes; their mechanical design; reflecting, diffusing and refracting media; projecting systems; color media; and equipment for the stage, advertising, studies, etc., are discussed. A section is also devoted to auxiliary equipment. The book, it is believed, will prove exceedingly useful to every one interested in the subject of equipment.

Industrial Accident Prevention; a Scientific Approach. By H. W. Heinrich. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 8 in., 366 pp., illus., tables, $4.

A very thorough presentation of the essential principles of accident prevention, based upon long practical experience. The author describes, step by step, the procedure for determining the causes of accidents, the selection and application of the remedy, safety, psychology, etc. Many good methods of guarding machinery are shown.

Internal Combustion Engines. By J. A. Polson. John Wiley & Sons, New York, 1931. Cloth, 6 × 9 in., 475 pp., illus., diagrams, charts, tables, $5.

A college text for students who understand thermodynamics and have some conception of the construction of internal-combustion engines. The book discusses the theory of the Otto and Diesel cycles, and presents and analyzes performance and test data for a large number of important types of engines.

Ludwig Loewe & Co. Aktiengesellschaft, Berlin, 1869–1929. Herausgegeben zum sechzigjährigen Jubiläum der Firma von der Gesellschaft für elektrische Unternehmungen. Ludwig Loewe & Co., Berlin. Cloth, 9 × 12 in., illus., portraits, 15 r.m.

This handsome volume celebrates the sixtieth anniversary of the founding of this well-known firm of machine-tool makers. Dr. Matschoss describes the evolution of the firm, which began as a maker of sewing machines, took up the manufacture of firearms, and finally entered the machine-tool field. Dr. Schlesinger describes the development of manufacturing and business methods.

Manufacture of Artificial Silk. By E. Wheeler. D. Van Nostrand, New York, 1931. Cloth, 6 × 9 in., 177 pp., illus., diagrams, tables, $5.

Gives a clear description of the essential chemical and engineering details of the modern methods of manufacturing rayon, and of its properties and uses. The viscose process is described at length, the others more briefly. References to patents and literature are included.

Maschinengetriebe (5 Vorträge der Getriebetagung 1930 in Dresden). By Verein Deutscher Ingenieure, Berlin. V.D.I. Verlag, G.M.B.H., 1931. Paper, 6 × 8 in., 59 pp., illus., diagrams, 4 r.m.

Five lectures upon gearing, delivered at a symposium of the German Engineering Society by various specialists. These lectures discuss various mechanical movements of importance and the different mechanisms by which they may be produced.

Mitteilungen der Deutschen Materialprüfungsanstalten; Sonderheft 14. Arbeiten aus dem Staatlichen Materialprüfungsamt und dem Kaiser Wilhelm-Institut für Metallforschung zu Berlin-Dahlem. Julius Springer, Berlin, 1930. Paper, 8 × 12 in., 91 pp., illus., diagrs. 13 r.m.

Sixteen papers presenting recent investigations at the National Testing Laboratory and the Kaiser Wilhelm Institut für Metallforschung. Improvements in methods of testing and the results of various researches upon the strength of materials are the topics of these reports.

Der Modellbau; die Modell- und Schablonenformerei. By Richard Löwer. Julius Springer, Berlin, 1931. Bound, 6 × 9 in., 229 pp., illus. 17.50 r.m.

An unusually thorough textbook on patternmaking, based upon evident practical experience. The author not only treats of the general principles of pattern-making, but also shows proper methods for a wide variety of machine parts, giving full details. A valuable feature is the attention paid to improper methods of work.

The Quantum Theory. By Fritz Reiche; translated by H. S. Hatfield and Henry L. Brose. E. P. Dutton & Co., New York, 1930. Cloth, 5 × 8 in., 218 pp., $2.10.

An excellent account of the origin and development of the quantum theory from its introduction to the present day, which does not make any great mathematical demands upon the reader. A bibliography and numerous references furnish ample guidance to students who wish to pursue the subject further.

Regeln für die Durchflussmessung mit Genormten Düsen und Blenden. V.D.I. Verlag, Berlin, 1930. Paper, 8 × 12 in., 20 pp., illus.

These rules have been prepared by a special committee of the Society of German Engineers. The theoretical equations are developed, the design of standard nozzles and orifices is explained and the permissible tolerances given, and the practical use of the rules illustrated.

Die Röntgentechnik in der Materialprüfung. By J. Eggert and E. Schiebold. (Ergebnisse der technischen Röntgenkunde, bd. 1.) Akademische Verlagsgesellschaft, Leipzig, 1930. Cloth, 6 × 9 in., 206 pp., illus., diagrams, 16.80 r.m.

Contains a course of lectures delivered by various specialists at the Charlottenburg Technical High School. These describe the principles of Roentgenology, the apparatus and methods used, and the ways in which X-rays are used to detect flaws in castings and welds, in chemical engineering, and in other branches of manufacturing. Much practical information is given.

Die Schmiermittel; ihre Art, Prüfung und Verwendung. By Richard Ascher. Second edition. Julius Springer, Berlin, 1931. Bound, 6 × 8 in., 302 pp., illus., diagrams, tables, 16 r.m.

Intended to give the dealer and the works engineer an understanding of the origin and preparation of various lubricants, and an account of their advantages and disadvantages. The common lubricants are described, and methods for testing and analyzing them are given. The proper oils for various purposes are shown, and methods of saving lubricants discussed. The book will be of use to engineers who wish a concise, practical reference book.

Springs and Suspension. By T. H. Sanders. Locomotive Publishing Co., London, 1930. Cloth, 6 × 9 in., 788 pp., illus. diagrams, tables, 30s.

A thorough review of spring arrangements for locomotives, railroad cars and coaches, street cars, and automobiles, and of springs for buffer and traction gear. The book discusses a great number of past and current methods of springing vehicles, and describes the practice of many railroads and vehicle builders. A continuation of the author's previous book on the design and manufacture of laminated springs.

Verdampfen Kondensieren und Kühlen. By E. Hausbrand. Seventh edition revised by M. Hirsch. Julius Springer, Berlin, 1931. Cloth, 6 × 9 in., 359 pp., illus., diagrams, 29 r.m.

Although issued as a new edition of Hausbrand's well-known work, this is practically a new book. To a larger extent than formerly, the theoretical principles are presented. Formulas and graphs replace many tables of numerical data. The technique of evaporating has been made the principal topic, and condensing and cooling are considered only in relation to evaporating plants.

The new work treats the subject much more systemtically and scientifically. The data required by the designer are given extensive discussion, and the construction and use of evaporating apparatus are treated.

Vollständige Zahlentafel und Diagramme für das Spezifische Volumen des Wasserdampfes bei Drücken zwischen 1 und 270 at. By H. Speyerer and G. Sauer. V.D.I. Verlag, Berlin, 1930. Paper, 8 × 12 in., 8 pp., 2.50 r.m.

These tables are based on the data of Knoblauch, Raisch, Hausen, Davis, and Smith. The tables extend from 100 deg. cent. to 550 deg. by ten-degree intervals. Values are given for each atmosphere below 120, and for each five atmospheres for higher pressures.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the current issues of Aeronautical Engineering and the Machine Shop Practice and Materials Handling sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

AERONAUTICAL ENGINEERING PAPERS

Progress in Aeronautics. [Paper No. AER-53-1]

This progress report is divided into seven sections and each is reviewed by a person closely associated with the work. The divisions include: Aerodynamics, airplane design and construction, air transport and other civil flying, naval aviation, military aeronautical equipment, airships, and American airways practice. Tables are given for mileage of air-mail routes, air-transport mileage, and accident statistics.

Trend in Aircraft-Engine Development. By Harold Caminez. [Paper No. AER-53-2]

It is difficult to ascertain the extent to which various improvements in aircraft engines will be adopted, and it is unwise to predict what the eventual types of aircraft power plants will be. However, a discussion of present-day aircraft engines with their possibilities and shortcomings is helpful in establishing some of the trends in engine development. The author discusses general features of aircraft engines, such as in-line versus radial types and water-cooled versus air-cooled types, and shows their limitations and advantages.

Some Economic Aspects of the Rigid Airship. By Carl B. Fritsche. [Paper No. AER-53-3]

In this paper the author tells of the uses to which rigid airships may be put, the cost of constructing, operating, and maintaining, and the probable return on investment that can be expected. Two hypothetical airships are chosen for comparison, one of 100 tons gross lift and the other of 300 tons lift. These are compared with ocean craft and with naval vessels. In naval application it is shown that one airship will release three cruisers for other duty, and that the cruisers consume more power and are more vulnerable than the airship.

Military applications of the airship include army transport, reconnaissance, coast patrol, and many other important uses. Theoretical conditions are assumed, and many problems are worked out with use of airships. Civil and commercial applications of the airship are discussed, and a comparison is made with the steamship *Leviathan*. Operating schedules are laid out for airships in service between New York, Philadelphia, Washington, Havana, and Panama, and performance data are given. Commercially the airship is shown supplementing present facilities, transporting passengers, mail, and express at high speed, doing more work per unit of energy, saving much time, and earning considerable profits.

Rubber in Airplane Construction. By C. Saurer. [Paper No. AER-53-4]

There are a large number of uses to which rubber can be put in airplane construction. Its ability to dissipate shocks and vibrations makes it useful for engine mountings, shock absorbers, and propeller insulators. It can also be used to produce a leakproof tank lining, for seat cushions, and as a lining for airplane cabins to insulate the passengers from outside noise and changes in temperature. The paper describes several types of construction in which rubber is used to advantage.

Airplane Tires and Wheels. By H. F. Schippel. [Paper No. AER-53-5]

This paper tells of some of the mounting conditions of airplane tires on wheels, and of the relation between static load, ultimate cushioned load, and energy capacity. Static and dynamic loading curves and corresponding hysteresis loops are also presented, and the forces and power losses are resolved horizontally and vertically. Results of extensive wind-tunnel tests show the effects of tire size, wheel size, safety-tread design, streamlining, and tire misalignment.

MACHINE-SHOP PRACTICE PAPERS

Case-Hardening With Ammonia Gas. By V. O. Homerberg and J. P. Walsted. [Paper No. MSP-53-1]

It has been the dream of metallurgists for many years to produce a steel of good toughness with maximum surface hardness and wear resistance. To produce these properties with a minimum of distortion has been the subject of much research work of a high order. In the past the most successful method of obtaining these properties has been by subjecting low-carbon steel to the action of a carburizing material at high temperatures. Under these conditions the steel takes up carbon in its surface layer, changing that portion of the material into a high-carbon steel capable of hardening, while the core remains low in carbon with the usual toughness and shock-resisting properties. By a suitable double heat treatment the core can be brought to maximum physical properties while the case can be made hard and wear-resistant. This process of case-hardening by means of carbon is somewhat cumbersome. The necessary heat treatment after carburizing is a frequent cause of distortion of the hardened parts.

A new process of case-hardening has been developed which has all the advantages of the older method. Besides being free from the troublesome warpage, it surpasses the older method in the hardness of the case produced. This new process, known as "nitriding," now a commercial success, is described by the authors in this paper.

Nitriding Analyses—Their Physical Properties and Adaptability. By R. S. Sergeson and M. M. Clark. [Paper No. MSP-53-2]

In this paper the authors give the range of analyses of the present chrome-aluminum-molybdenum nitriding steels. The physical properties of these analyses are given in detail both in regard to tensile and impact values. Some data on fatigue tests have been added. Mention is made as to the proper quenching temperatures, and there is a suggestion as to the amount of stock to be removed for elimination of decarburized surface obtained previous to machining. Many applications which are operating highly successfully are given.

Replacing Metals by Synthetic Resins—Phenol-Resinoid Molding Technique. By Leon V. Quigley. [Paper No. MSP-53-3]

It is the purpose of this review to assist the engineer and mechanic whose experience has been chiefly with metals to get his bearings with regard to the synthetic resin plastics, which are becoming increasingly important in the metal trades. The paper deals particularly with that type of plastic or synthetic resin materials known as phenol resinoids. The review has involved a study of the literature of America, England, and the Continent covering the past five years, and relies also upon the technical archives of the American company which, during the past 20 years, since the inception of these materials, has been engaged in their manufacture.

Repair of Worn Parts by Electrodeposition of Iron. By T. P. Thomas. [Paper No. MSP-53-4]

In this paper a commercial method is described for salvaging worn or undersized steel parts, such as thread and plug gages, arbors, reamers, motor shafts, gear centers, etc., by electrodeposited iron. Details of the process have been worked out which provide a practicable set of instructions for shop use. The high current efficiency and rate of deposit of the warm concentrated sulphate bath will enable the plater to complete practically any salvage job in one working day.

Arc-Welded Jigs, Fixtures, and Machine Tools. By J. R. Weaver. [Paper No. MSP-53-5]

Among the advantages of jigs and fixtures welded up from structural-steel shapes over those of cast construction, the author cites production on short notice, strength combined with comparative lightness in weight, ease of alteration, etc. He outlines the methods used in their manufacture, and gives examples of a wide variety of jigs and fixtures and of special machine tools embodying this form of construction.

MATERIALS HANDLING PAPERS

Progress in Materials Handling. [Paper No. MH-53-1]

This report comments on some of the important new developments in equipment and methods used for handling materials. The work of compilation was divided among persons familiar with that particular field. Among the different equipment discussed are: overhead traveling cranes; electric hoists and cupola-charging machines; conveyors; drive chain, variable-speed gears, and skip hoists; pneumatic tubes; hand-lift trucks and portable elevators; electric industrial trucks; gasoline trucks and tractors; industrial elevators; motor trucks and trailers; locomotive cranes; bridges, car dumpers, towers, and handling systems for bulk materials; industrial-railway equipment; and wire-rope tramways. There is also a discussion of the application of electrical equipment to materials-handling machinery, and of variable-speed transmission systems.

Materials Handling in the Shoe Industry. By K. D. Hamilton. [Paper No. MH-53-2]

The growth of the shoe industry is discussed from its earliest establishment, from the point of view of mechanical handling of products. The author describes the typical factory-production problem and the development of the mechanical conveyor in shoe factories. Mechanical drying and tempering of leather, as well as the adaptation of the individual motor to shoe machinery, are described, and also the installation of standard equipment for power house, dust collecting, packing, and shipping, to show that the shoe industry is searching for all methods to reduce production costs.

Materials-Handling Methods in the Fisk Tire Plant. By C. E. Maynard. [Paper No. MH-53-3]

This paper discusses the part that handling equipment has played in a program of cost reduction and quality improvement in the Fisk Tire Company's plant. In recent years there has been a tendency for the plant to become more "conveyorized," coordinating groups of operations. The Trucking and Mechanical Departments are mainly responsible for the materials-handling equipment. The Engineering Department, a subdivision of the Mechanical Department, is expected to develop improvements. The cost of improvements has to be justified by a reduction in operating cost or an improvement in quality. There are no limitations on the cost of materials-handling equipment provided a saving can be made within a reasonable length of time. Comparing trucking costs of 1925 with the present, a 50 per cent reduction is noted. In spite of the tremendous savings that have been made in materials-handling methods during the last four or five years, the possibilities of further improvement are far from being exhausted.

Handling Materials at the Postum Company. By P. P. Pratt. [Paper No. MH-53-4]

This paper offers a discussion of various types of conveyors in general use, together with descriptions of a few specialized conveyors. Practically every phase of manufacturing at the Postum plant embraces operations performed on the material in course of handling—especially is this true of modern automatic packaging machinery referred to in this paper. An enlarged section treats of the operation and mechanical details of the "intercommunicating pilot-car package-conveying system," used as a connecting link between shipping points. This system automatically handles a wide variety of cased products and offers selective loading at each of four shipping points. It has effected quite considerable economies, and has made it possible to utilize widely separated storage spaces, more or less as a unit.

NOTE: Those who have not registered in the A.S.M.E. Aeronautic, Machine Shop Practice, and Materials Handling Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

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AIRPLANE ENGINES

Heat Treatment of Parts. The Heat Treatment of Aircraft Engine Parts, R. R. Moore. Fuels and Furnaces, vol 9, no. 3, Mar. 1931, pp 279–289, 13 figs. Importance of proper heat treatment of various parts of airplane engine, both steel and aluminum alloy; various methods by which heat treatment may be accomplished and physical and chemical properties desired in different parts.

AIRPLANES

Amphibian. Towle All-Metal Amphibian Flying Boat. Aero Digest, vol. 18, no. 2, Feb. 1931, pp. 58–59, 4 figs. Design and specifications of Towle model TA-3 amphibian powered by Diesel engines of 225 hp. each as standard equipment; span, 56 ft.; weight empty, 3943 lb.; gross weight, 6200 lb.; wing loading 15.28 lb. per sq. ft.; power loading, 13.20 lb. per hp. high speed, 120 m.p.h.

Design. L'evoluzione aerodinamica del velivolo nell'ultimo decennio (Aerodynamic Evolution of Airplane in Last Decade), C. Pallavicino. Atti del Sindacato Provinciale Fascista Ingegneri di Milano, vol 8, no. 11, Nov. 1930, pp. 429–436, 17 figs. Review of general principles of airplane flight including principles of helicopters and autogiro, relative importance of factors controlling aerodynamic efficiency of wing and of complete plane; examples of stream lining with particular regard to engine cowling systems.

Light-Weight Alloy for. The Use of Elektron Metal in Airplane Construction, E. I. de Ridder. Nat. Advisory Committee for Aeronautics—Tech. Memo. no. 608, Feb. 1931, 22 pp., 46 figs. Manufacturing process and physical properties of electron made by I. G. Farben Industrie, Bitterfield, Germany; practical examples illustrate advantages of light weight of elektron alloys in construction of airplane and airplane engines. From Jahrbuch 1929 der Wissenschaftlichen Gesellschaft fuer Luftfahrt.

Performance Calculation. A New Chart for Estimating the Absolute Ceiling of an Airplane, W. S. Diehl. Nat. Advisory Committee for Aeronautics—Report no. 368, 1930, 7 pp., 7 figs. Derivation of charts to be used in conjunction with usual curves of power required and power available as accurate substitute for extended calculation, or in estimation of absolute ceiling when power curves are not available.

Sur les plus grandes distances franchissables en avion (Maximum Disk Negotiable by Airplane), G. A. Mokrzycki. Aerophile, vol. 38, no. 11, Feb. 15, 1931, pp. 50–51, 1 fig. Application of formulas for calculating range of airplane as function of useful load, total load including fuel, and net weight of plane.

Propellers—Design. Das Verhalten der Kennziffern von Holzluftschrauben bei Umfangsgeschweindigkeiten bis 280 m. sec. (Characteristics of Wooden Propellers at Tip Speeds Up to 280 m. per Sec.), F. Weinig. Zeit fuer Angewandte Mathematik und Mechanik, vol. 10, no. 6, Dec. 1930, pp. 525–539, 8 figs. Investigation of factors influencing efficiency such as viscosity of air, centrifugal forces, relations between speed and stresses, and application of results to flight tests of propellers.

The Equilibrium of Loaded Impeller Blades with Special Reference to the Strength of Thin Metal Airscrews, P. A. Ralli. Roy. Aeronautical Soc.—Jl., vol. 35, no. 242, Feb. 1931, pp. 121–165, 16 figs. Mathematical investigation of equilibrium of loaded blade for variable pitch distribution; equilibrium of loaded blade for approximately constant pitch; practical application to "Fairey 111.F. Panther" metal airscrew; case: full throttle flight at 10,000 ft.

Wing Beams. Development of Steel Wing Beams for Aircraft, H. C. Knerr and H. A. Backus. Iron Age, vol. 127, no. 9, Feb 26, 1931, pp. 706–710, 6 figs. Advantages of alloy-steel, wing beam with tensile strength of 250,000 to 300,000 lb. per sq. in.; data on heat treatment and construction developed by various airplane builders including Stinson, Fairchild, and Chance-Vought.

ALIGNMENT CHARTS

Development. Les progrès des procédés mécaniques et graphiques de calcul depuis cinquante ans (Progress in Mechanical and Graphical Computation Processes for 50 Years), M. d'Ocagne. Génie Civil, 50th Anniversary Number, 1930, pp. 8–11, 5 figs. Historical review of development of mechanical calculating machines and graphical methods of computation, with special reference to nomography.

ALLOY STEEL

See STEEL, Alloy.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bearing Metals. See BEARING METALS.

Beryllium. See BERYLLIUM ALLOYS.

Magnesium. See AIRPLANES, Light-Weight Alloys for.

ALUMINUM

Castings. Aluminiumguss im Dieselmotorenbau (Aluminum Castings in Diesel Engine Design), W. Hartl. Automobiltechnische Zeit., vol. 34, no. 4, Feb. 16, 1931, pp. 94–98, 31 figs. Practical examples illustrate proper utilization of light metals in highly stressed castings; data on physical properties and methods of reducing notch effect.

Foundry Practice. A Survey of Light-Castings Manufacture, F. Harris. Foundry Trade Jl., vol. 44, no. 755, Feb. 5, 1931, pp. 107–109, 8 figs. Melting plant used; preparing cupola; preparing hearth; lighting up; charge used; overcoming troubles; preparation of facing sands; making pattern plates; closing mold; facing sands; aluminum melting practice; molding aluminum castings.

ALUMINUM ALLOYS

Aluminum-Silicon. Giessbarkeit sowie mechanische und chemische Eigenschaften der Alumiuium-Silizium-Legierungen (Casting Properties, Mechanical and Chemical Properties of Aluminum-Silicon Alloys). Zeit. fuer die Gesamte Giessereipraxis, vol. 52, no. 4, Jan. 25, 1931 (supp.) pp. 17–18. Difficulties involved in obtaining good alloy of aluminum and silicon; properties of silumin are compared with those of other aluminum alloys.

Aluminum-Titanium. Constitution of High-Purity Aluminum-Titanium Alloys, W. L. Fink, K. R. Van Horn, and P. M. Budge. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 393, 18 pp., 13 figs. Investigation of phase relations, as part of fundamental research program of laboratories of Aluminum Company of America; preparation of alloys; chemical and thermal analysis; determination of luquidus; metallographic structures; composition of aluminum-titanium constituent; crystal structures; aluminum end of constitutional diagram of aluminum-titanium system. Bibliography.

AMMONIA COMPRESSORS

Efficiency. Volumetric Efficiency of a Vertical Single-Acting Ammonia Compressor, J. C. Reed and E. E. Ambrosius. Refrig. Eng., vol. 21, no. 3, Mar. 1931, pp. 176–181 and (discussion) pp. 181–182 and 202, 7 figs. Purpose of investigation to study existing data regarding real volumetric efficiency and to perform such tests as were necessary to obtain real volumetric efficiency of vertical, single-acting, ammonia compressors; secondary purpose to compare existing empirical formula with results obtained from tests; test equipment, experimental procedure, and test results; sample calculations and bibliography.

Multiple-Effect. Advantages of Multiple-Effect Ammonia Compressors, R. S. Wheaton. Power, vol. 73, no. 9, Mar. 3, 1931, p. 374, 2 figs. Multiple-effect design of compressor finds excellent application in refrigerating plants where two widely varying temperatures are maintained and in ice-making plants where water is forecooled at higher temperature than that temperature at which water is frozen; indicator diagram of multiple-effect compressor; work done by high and low suctions.

AUTOMOBILE ENGINES

Bearings. Fits and Tolerances in Automotive Engine Bearings. Am. Mach., vol. 74, no. 11, Mar. 12, 1931, pp. 423–424. Data on bearing tolerances and assembly of 7 prominent builders;

notes on use of shims and finishing operations, lapping, grinding, and reaming.

Diesel. See DIESEL ENGINES, Automotive.

Manufacture. Franklin Crankcases and Multi-Purpose Tools, O. R. Miller. Am. Mach., vol. 74, no. 10, Mar. 5, 1931, pp. 383–386, 6 figs. Machining methods and equipment with data on tolerances; operations on Newton miller and Cincinnati Hydromatic; side view and typical section of aluminum crankcase.

Oil. See OIL ENGINES, Automotive.

Starting. Thermostatic Control of Crankcase Oil Is a Much-Needed Development, A. E. Becker. Automotive Industries, vol. 64, no. 10, Mar. 7, 1931, pp. 401–405 and 415, 8 figs. Investigation of relation of friction hp. to starter hp. and engine power at low speeds; as real controlling factor in starting internal combustion engines at low temperatures; graphs illustrate cold-starting requirements; cold-pumping characteristics of several oils.

AUTOMOBILES

Brake-Linings. Latex-Bonded Brake Lining Has Nearly Constant Coefficient of Friction and Does Not Swell, J. A. Lunn. Automotive Industries, vol. 64, no. 8, Feb. 21, 1931, pp. 270–273, 8 figs. Advantages of latex-bonded asbestos lining; proper distribution of binder in flexible or rigid linings helps to eliminate noise and reduce wear; microphotograph illustrates structure of lining after subjections to temperature of 600 deg. fahr. for three hours.

Design. A propos du chassis naturellement indéformable (Problem Relating to Naturally Rigid Chassis), N. Causan. Vie Automobile, vol. 27, no. 963, Feb. 10, 1931, pp. 48–52, 6 figs. Study of chassis design problems with particular regard to methods of improving road holding ability; design, mounting, and functioning of springs; design for obtaining lateral stability.

Skidding. Ein einfacher Weg zur genauen Bestimmung der Reibungsziffer zwischen Kraftwagenbereifung und Fahrbahn (Exact Determination of Friction Coefficient Between Motor-Vehicle Tires and Road Surface), Deiters. Automobiltechnische Zeit., vol. 34, no. 4, Feb. 14, 1931, pp. 87–89, 3 figs. Investigation of friction coefficient by means of breaking of one wheel only; calculation of forces caused by breaking; effect of load distribution.

B

BALANCING MACHINES

Types. The Balancing of Machinery, C. N. Fletcher. Mech. World, vol. 89, nos. 2301, 2303, and 2305, Feb. 6, 1931, pp. 128–131, Feb. 20, pp. 180–181, and Mar. 6, pp. 224–226, 14 figs. Feb. 6: Resonance; critical speed; angle of log; Davey portable dynamic balancing equipment. Feb. 20: G. W. R. balancing machine; special purpose balancing equipment; Olsen-Lundgren tire balancing machine; Defiance patent flywheel balancing machine. Mar. 6: Kunze flywheel balancing machine; Olsen-Lundgren static dynamic flywheel balancing machine; Krupp-Losenhausen special production type balancing machine and vertical equipment for balancing centrifugal containers; Olsen dynamic propeller shaft balancing machine.

BEARING METALS

Bronze. Die Carobronze als Lagermetall in der Automobile Automobilindustrie (Caro Bronzes as Bearing Metals in Automobile Industry), Schulz. Metallwirtschaft, vol. 9, no. 47, Nov. 21, 1930, pp. 969–970, 4 figs. Caro bronzes contain about 92 per cent copper, 8 per cent tin, and 0.25 per cent phosphorous, and can be cold-drawn into tubes which may be cut into sections of desired length for bearing bushes.

Properties. Bearing Metals Containing Aluminium or Both Aluminium and Nickel, Nishimura. Japanese Gov. Ry.—Bul., vol. 19, no. 4, Jan. 25, 1931, 43 pp., 89 figs. Kyoto Imperial University has patented bearing alloys which contain aluminium or both aluminium and nickel, and has recommended them for use in rolling stock; comparative examination made into performance of alloys and white metals; according to results of experiment, metals are somewhat better than those containing no aluminum. (Brief abstract in English.)

BEARINGS, BALL

Heat Treatment. Heat Treatment of High-Duty Bearing Balls, R. E. Coward. Iron and Steel, vol. 14, no. 1, Jan. 1931, pp. 3–4 and 17–19, 3 figs. General procedure of heat treatment; hardening, quenching, and tempering; rotary furnaces have many advantages; stationary furnaces used for large balls; cupola process. From Black and White.

Preloading. Procedure in Preloading, H. W. Holdsworth. Am. Mach., vol. 74, no. 7, Feb. 12, 1931, pp. 269–272, 5 figs. Determination of load distribution, and total actual deflection caused by external load, by use of deflection curves; sketches illustrate application of preloading principle in ball-bearings spindle mount design; chart shows graphically how initial preload actually reduces deflection under operating conditions.

BEARINGS, JOURNAL

Lubrication. Oil Film Pressures in a Complete Bearing, L. J. Bradford and L. J. Grunder. Penn State College—Eng. Experiment Station—Bul. no. 39, vol. 24, no. 40, Sept. 8, 1930. Historical review of research work in field of bearing friction and lubrication; work undertaken to supply information upon actual film pressures within complete journal bearing, lubricated from one end and also to determine running positions of journal; apparatus and method of testing; curves illustrating test results of various oils at different pressures.

Thrust, Pressure Distribution in. Die Druckverteilung im Spurzapfen (Pressure Distribution in Thrust Journals), F. Kuba. Zeit. des Oesterre chischen Ingenieur und Architekten Vereines, vol. 83, nos. 3–4 and 5–6, Jan. 23, 1931, pp. 15–17 and Feb. 6, pp. 33–37, 5 figs. Development of equation for pressure distribution with particular regard to determination of optimum pressure distribution in conic thrust journal, and in thrust journals with one and two rings.

BERYLLIUM ALLOYS

Beryllium-Copper. Beryllium-Copper Alloys, E. R. Thews. Can. Chem. and Met., vol 15, no. 2, Feb. 1931, pp 51–53, 1 fig. Occurrence; price; production by electrolytic process; properties of beryllium; use as addition to alloys; effect of age hardening; beryllium bronzes.

BLAST FURNACES

Great Britain. The New Ford Blast Furnace at Dagenham, P. J. Hale. Foundry Trade Jl., vol. 44, no. 753, Jan. 22, 1931, p. 69, 1 fig. Units comprising initial construction, include manufacturing and assembly buildings, foundry buildings, power and boiler plant, coke-oven and by-products plant and blast-furnace plant; latter includes one 500-ton furnace with double skip, three Schiffer-Strack hot-blast stoves, stock bins, Theisen disintegrator gas-cleaning plant, ore-storage yard, pig-casting machine, waste-water clarifier, sintering plant, together with necessary gas, air, water, and sewer mains.

BOILERS

Corrosion. Der Einfluss der Dampfentwicklung auf die Kesselstein und Schlammbildung im Dampfkessel und im Verdampfer (Influence of Steam Formation on Boiler Scale and Sludge Formation in Boilers and Evaporators), R. Stumper. Feuerungstechnik, nol. 19, no. 1, Jan 15, 1931, pp. 3–6, 11 figs. Characteristic of present status of water problem in steam power plants; precipitation of insoluble admixtures of boiler content; influence of steam generation; necessity of increasing water circulation; new ways of reducing boiler-scale formation.

Ueber die Bestimmung des Waermeleitvermoegens bei Kesselstein (Boiler Scale), H. Biskamp. Zeit. fuer Technische Physik, vol. 12, no. 1, Jan. 1931, pp. 30–33, 4 figs.; see also brief translated abstract in Chem. and Met. Eng., vol. 38, no. 2, Feb. 1931, p. 103. Highly corrosive scale also is always full of occluded air, i.e., highly porous; analysis showed that such scale always contained silicates as well as mixed sulphates and carbonates; further study has revealed that relation between porosity and thermal conductivity is linear, so that either can be calculated when other is known; porosity measurement can be made with few grams of scale in small bits.

Design. Double Cross-Drum Boilers in Hell Gate Extension Each Produce 1,000,000 lb. of Steam an Hour. Power, vol. 73, no. 9, Mar. 3, 1931, pp. 356–370, 7 figs. Air-cooled slag-bottom furnaces, induced- and forced-draft fans driven by compound turbines, and pulverizers operating under air pressure instead of suction are features of new boiler house; cross-section of double cross-drum boiler; diagrammatic layout of coal-handling equipment for transporting fuel from old boiler house to new extension; list of equipment data, Hell Gate additions.

Marine. Water-tube and Scotch Boilers. Engineer, vol. 151, no. 3919, Feb. 20, 1931, pp. 220–221, 2 figs. Symposium on relative fields of development of water-tube and Scotch boiler in merchant service at Institute of Marine Engineers, Feb. 10; case for water-tube boiler was presented in contribution by H. B. Yarrow; papers on Scotch boiler, by S. Hunter, Jr., and S. R. Dight of Admiralty Fuel Experimental Station.

Pulverized-Coal. Belastung von Staub-Feuerraeumen (Loading of Pulverized Coal Furnaçes), P. Rosin and R. Fehling. Waerme, vol. 54, no. 3, Jan. 17, 1931, pp. 42–50, 15 figs. Based on relations for equilibrium between combustion and heat transmission, influence of size, shape, and cooling of furnaces, air admission and combustion velocity of coal dust on permissible furnace load and temperature is investigated; radiation properties of pulverized-coal flame.

Ein Beitrag zur Loesung der Grosskesselfrage (Contribution to Problem of High-Capacity Boilers), P. Giesecke. Waerme, vol. 54, no. 3, Jan. 17, 1931 pp. 61–62, 4 figs. Results of tests of Lopulco pulverized-coal radiant boiler installation in power plant of Ruhr Chemie A.G. in Sterkrade-Holten, with 600 sq. m. heating surface for steam at 20 atmos., equipped with air preheater of 1500 sq. m.

Water-Tube—Depreciation. Betriebsdauer und Wirkungsgrad von Wasserohrkesseln mit Gas und Kohlefeuerung (Length of Time in Operation and Efficiency of Water-Tube Boilers With Gas or Coal Firing), R. Orel. Waerme, vol. 54, no. 3, Jan. 17, 1931, pp. 54–56, 2 figs. Investigation of period of time in which losses due to diminishing efficiency are offset by costs of cleaning; comparison of oil-gas and traveling-grate firing system and determination of best fuel distribution for simultaneous operation of both furnace systems for different boilers.

C

CABLEWAYS

Quarry. Limestone Transportation, C. K Traber. Eng. and Min. Jl., vol. 131, no. 5, Mar. 9, 1931, pp. 206–207, 4 figs. Single-span two-bucket tramways at plant of Olympic Portland Cement Co., 30 mi. northeast of Bellingham, Wash., for transporting crushed limestone; hump in profile made intermediate transfer station necessary; first stage 740 ft. horizontal, 357 ft. vertical; second stage, 1060 ft. horizontal and 642 ft. vertical; operated two yrs., exceeding rating capacity of 150 tons per hr.; carrying cables $2^1/_4$ in. diam., locked-coil; head ropes $^7/_8$ in., tail rope $^3/_4$ in.; carriers 80 cu. ft. capacity, with four-wheel trucks.

CALCULATING MACHINES

Development. Les progrès des procédés mécaniques et graphiques de calcul depuis cinquante ans (Progress in Mechanical and Graphical Computation Processes for 50 Years), M. d'Ocagne. Génie Civil, 59th Anniversary Number, 1930, pp. 8–11, 5 figs. Historical review of development of mechanical calculating machines and graphical methods of computation, with special reference to nomography.

Gears of. Getriebe der Addiermaschine (Gears of Adding Machines), W. Lind. V.D.I. Zeit., vol. 75, no. 7, Feb. 14, 1931, pp. 201–205, 17 figs. Design and operation of mechanism of adding machines; sketches illustrate designs of Burroughs and Dalton.

CAMS

Design. Der Entwurf von Kurventrieben mit Ruecksicht auf den Beschleuningungsverlauf (Design of Curve Drive With Regard to Acceleration Characteristics), W. J. Hoehere. Maschinenkonstrukteur, vol. 64, no. 3, Feb. 10, 1931, pp. 30–34, 12 figs. Kinematic study of various types of curve drives with particular regard to obtaining suitable acceleration characteristics; determination of velocity and acceleration by means of vectors; data on design of curve milling machines.

CAR DUMPERS

Grain Unloading. Grain Cars Unloaded in Six Minutes, W. F. Gorton. Elec. Jl., vol. 28, no. 3, Mar. 1931, pp. 150–151, 4 figs. Device for unloading box cars installed at plant of National Milling Company, Toledo, Ohio, is described; it consists of section of track so mounted that freight car can be tilted sideways and then rocked endways to spill bulk grain from car; photoelectric tube is used in connection with this.

CARS, REFRIGERATOR

Design. Mechanical Refrigeration for Railway Freight Cars, E. R. Rowledge. Cold Storage vol. 34, no. 395, Feb. 18, 1931, pp. 34–36, 5 figs. Lightfoot-Stone automatic axle drive system; thermograph record of even temperature maintained on Ellarcold-Stone car; mechanical refrigeration arrangement on chassis.

CASE HARDENING

Depth of Case. A Practical Method of Obtaining the Depth of Carburized Case, J. Sorenson. Fuels and Furnaces, vol. 9, no. 3, Mar. 1931, pp. 329–331. Method of checking approximate depth of case-hardened steels by use of Brinell hardness testing machine.

Nitriding Furnaces. Temperature Control a Feature of New Nitriding Furnace, J. H. Knapp. Steel, vol. 88, no. 8, Feb. 19, 1931, pp. 38 and 40. 3 figs. Design and operation of gas-fired furnace developed by James H. Knapp Co., Inc., Los Angeles; sketch of gas burner, showing arrangement for blowing cold air around combustion zone; regulating mechanism will vary amount of gas and air supplied to burners and therefore will vary input of heat to furnace between predetermined limits.

CHIMNEYS

Design. The Economical Design of Natural-Draft Chimneys, J. G. Mingle. Power, vol. 73, no. 9, Mar. 3, 1931, pp. 364–367, 4 figs. Rational formulas for chimney proportions including cost as well as all physical factors that affect problem; charts and table permit rapid determination of most economical size of natural-draft chimneys for typical atmospheric and temperature conditions; basic formulas presented are applicable to any conditions.

CLUTCHES

Friction. Reversal of High-Speed Spindles by Friction Clutches, J. A. Hall. Product Eng., vol. 2, no. 2, Feb. 1931, pp 52–55, 4 figs. Mathematical and graphical determination of time required for reversing clutches during engagement, amount of slippage at surfaces of clutch and of belt, energy lost in heat at each of these places, and total energy required; methods in study based on experimental work done on high-speed automatic screw machines at Brown & Sharpe plant.

COAL HANDLING

Conveyors for. Selecting a Cable for a Button Conveyor, H. F. Geist. Coal Age, vol. 36, no. 1, Jan. 1931, pp. 15–16. 5 figs. Supplement to paper indexed in Engineering Index 1930, from issue of Dec. 1930; mathematical calculation by which size of cables to be used in any given instrument is determined; formulas, charts, and tabular data.

CRANES

Design. Zulaessige Spannungen und Dauerfestigketi im Kran- und Verladebrueckenbau (Admissible Stresses and Fatigue of Materials in Design of Crane Stress), B. Gerlepp. Maschinenbau, vol. 10, no. 3, Feb. 5, 1931, pp. 86–90, 6 figs. Review of principal factors relating to fatigue of material in crane design with tables giving data on admissible stresses for various types of steel and cast iron.

Traveling. Overhead Travelling Cranes, A. R. Glithero. Mech. Handling, vol. 18, no. 2, Feb. 1931, pp. 51–54, 6 figs. Belonging to intermittent class of handling appliance, traveling crane, has proved itself most efficient appliance for service in engineering shops, foundries, steel works, power stations, and, in fact, all large industrial factories where site conditions permit erection of gantry; author discusses outdoor services in timber yards, railway freight yards, shipbuilding yards.

CUPOLAS

Charging. Novel Cupola Charging System, R. Abel. Matls. Handling and Distribution, vol. 5, no. 5, Feb. 1931, pp. 54 and 56, 3 figs. Design and operating features of cupola-charging installation in plant of C. B. Cottrell and Sons, Westerly, R. I., manufacture of printing presses and allied machinery for printing and newspaper business.

CUTTING METALS

Drilling—Power Requirements. Torque, Thrust and Power for Drilling, O. W. Boston and C. J. Oxford. Soc. Automotive Engrs.,—Jl., vol. 28, no. 3, Mar. 1931, pp. 378–383, 4 figs. Tests on drilling various grades of steel and cast iron conducted at University of Michigan and formulas, tables, and charts for determining thrust, torque, and horsepower that will be required in practice for drilling with drills of $1^{1}/_{2}$ in. or smaller diameter in various materials commonly used in industry.

CUTTING TOOLS

Tantalum Carbide. Cemented Tantalum Carbide a New Tool Material. Metal Progress, vol. 19, no. 3, Mar. 1931, pp. 53–55, 3 figs. Properties, application, and performance of tantalum-carbide tools bonded with strong and ductile nickel perfected by Fansteel Products Co., North Chicago, Ill.; material has a melting point of 4400 deg. cent.

D

DIES

Punching. Links and Link Tools, W. H. Malliet. Am. Mach., vol. 74, nos. 10 and 11, Mar. 5, 1931, pp. 393–394 and Mar. 12, pp. 437–438, 11 figs. Manufacturing operations and equipment in making links of wire from 0.040 to 0.085 in. diam. for use in calculating machines, typewriters, etc.; design of dies and fixtures.

Vorteile der Vereinheitlichung beim Schnitt und Stanzenbau (Advantages of Standardization in Designs and Punch Stresses), A. Peterhans. Maschinenbau, vol. 10, no. 4, Feb. 19, 1931, pp. 119–122, 14 figs. Importance of work done by punch-press committee of AWF; sketches illustrate principal types of punching dies.

DIESEL ENGINES

Automotive. A Survey of Mobile-Type Diesel Engines, G. G. A. Rosen. Soc. Automotive Engrs.—Jl., vol. 28, no. 3, Mar. 1931, pp. 301–305 and (discussion) 305–306, 3 figs. Major problems involved in designing of high-speed Diesel engines, combustion-chamber design; fuel-injection methods and devices; flexibility in utilization of variety of cheap, low-grade fuels; completeness and smoothness of combustion; reduction of vibration; and low first cost and maintenance.

Die MWM-Fahrzeug-Die selmotoren (MWM-Automotive Diesel Engines), H. Suder. Deutsche Motor-Zeit., vol. 8, no. 2, Feb. 1931, pp. 40–42, 6 figs. Design and specifications of types SS 15 V and SS 15s built by Motorenwerke Mannheim vorm. Benz, A.-G.; developing 60 and 90 hp. at 1500 r.p.m. as 4 and 6-cylinder engine, respectively; bore and stroke are 105 by 150 mm.; injection pressure 80 to 100 atmos.

Fuel Injection. A New British Fuel Pump for Oil Engines. Commercial Motor, vol. 53, no. 1355, Mar. 3, 1931, pp. 88–90, 5 figs. Design and operating principles of Benes pump which can be adjusted while engine is running, obviates side thrust upon pistons and will work at high pressures up to 300 atmos.

New Details of Diesel Practice. Diesel Power, vol. 9, no. 2, Feb. 1931, p. 91, 1 fig. Method of operating common-rail fuel-injection system which separates metering needle from spray orifice has been applied to engine of Cooper-Bessemer Corporation; design features of dual-tension spray needle.

High-Speed. The Sandon Two-stroke Cycle, Heavy-Oil Engine. Shipbldr. and Mar. Engine-Bldr., vol. 38, no. 248, Feb. 1931, pp. 146–149, 3 figs. New design of high-speed engine with airless injection; principles of design will be developed for all types of land and marine lighting sets, for propulsion of vessels of small size and also as light engine for driving motor vehicles; 3-cylinder unit described has cylinder diam. of $8^{3}/_{4}$ in. and stroke of $11^{3}/_{4}$ in.; develops 120 b.hp. when running at 450 r.p.m.; compression pressure is 450/4600 lb. per sq. in., and combustion pressure 600/625 lb. per sq. in.

Manufacture. The Production of Heavy Oil Engines. Machy. (Lond.), vol. 37, no. 958, Feb. 19, 1931, pp. 665–671, 15 figs. Machining operation on cylinder heads; facing and boring inlet, exhaust, and self-starter valve holes; machining operations on crankshafts with data on tolerances, feeds, and speeds.

Marine—Vibrations in. Torsional Vibration Frequencies of Marine Diesel Installations, J. Lockwood Taylor. Engineering, vol. 131, no. 3397, Feb. 20, 1931, pp. 259–260, 1 fig. Attempt is made to deduce frequency equation in which it is only necessary to substitute appropriate data, shaft lengths, stiffnesses and moments of inertia for any installation; various solutions of this equation give immediately natural frequencies of various modes and hence critical speeds; this greatly reduces labor and avoids necessity for any graphical work.

Two-Cycle. Spuelung und Leistung bei Zweitaktomotoren (Scavaging and Output in Two-Cycle Engines), K. Wintterlin. V.D.I. Zeit., vol. 75, no. 6, Feb. 7, 1931, pp. 165–169, 15 figs. Theoretical investigation of relations between scavenging process and power output, and graphical representation of results; relations between fresh air content, excess air, and maximum indicated power; comparison of different types of engine.

DYNAMOMETERS

Electric. The Dynamo-Electric Machine as a Dynamometer, B. P. Haigh. Engineering, vol. 131, no. 3394, Jan. 30, 1931, pp. 129–131, 12 figs. Modifications required to enable standard dynamo or motor to measure torque in its shaft, and certain precautions that should be observed in order to obtain accurate results; examples installed in Engineering Laboratory of Royal Naval College, Greenwich, are illustrated.

E

ELASTICITY

Theory and Experiment. Idées actuelles sur la resistance des matériaux (Present Day Ideas on the Resistance of Materials), A. Caquot. Génie Civil, 50th Anniversary Number, 1930, pp. 189–192, 7 figs. Review of recent theoretical and experimental studies on elastic resistance to compression, tension, shear, hydrostatic tension, and compression; theory of adaptation.

ELECTRIC FURNACES

Annealing. Recent Developments in the Design of Electric Annealing Furnaces for Metals, W. Meckenhauser. Metal Industry (Lond.), vol. 38, no. 6, Feb. 6, 1931, pp. 159–162, 7 figs. Progress and invention in sphere of electric annealing; possibility of high average load factor; full automatic control; continuous strip annealing furnaces.

Heat-Treating. A New Cyanide Furnace, R. F. James and G. Coley. Franklin Inst.—Jl., vol. 212, no. 3, Mar. 1931, pp. 327–334, 3 figs. Furnace was placed on trial in plant of Gemmer Manufacturing Company of Detroit for life test under operating conditions; this service was as severe as any cyanide pot service because of heavy production required from these pots; they are used for hardening steering-gear sectors and maximum production per hour is required.

Electric Furnaces and Low-Temperature Treatments, J. E. Oram. Metallurgia, vol. 3, no. 15, Jan. 1931, pp. 94–96, 5 figs. Low-temperature heat-treatments offer additional scope to electric furnace; low operating and maintenance cost and ease of temperature control are associated with this type of equipment.

ELECTRIC REGULATORS

Automatic Industrial. Automatic Regulators in Industries, J. H. Ashbaugh. Am. Inst. Elec. Engrs.—Advance Paper, no. 36, for mtg. Jan. 26–30, 1931, 8 pp., 20 figs. Progress has been rapid in past few years with result that there is available number of different regulators having wide fields of application; fundamental theory of all regulators is explained with effect of high and low inertias; regulators can be used to either improve quality of manufactured product, reduce cost, simplify operation, reduce amount or size of equipment, or reduce power bills on purchased power.

ELECTRIC WELDING

Arc. A New System for Direct Current Arc Welding, S. R. Bergman. Am. Inst. Elec. Engrs.—Advance Paper, no. 19, for mtg. Jan. 26–30, 1931, 3 pp., 4 figs. Short description of d.c. generator having characteristics suitable for arc welding; curves showing performance under steady conditions of load are shown; for quick changes of load transients appear detrimental to arc welding; to eliminate these transforming reactor is introduced in arc welding circuit; transforming reactor which has dual purpose; depresses transients and introduces reactance in arc circuit which, experience has shown is desirable in order to make arc stable and therefore easy to handle.

Einfluss der Schweissstrombedingungen bei der elektrischen Lichtbogenschweissung von weichem Flussstahl (Influence of Welding Current Requirements in Arc-Welding of Low Carbon Steel), N. Lefring. V.D.I. Zeit., vol. 75, no. 8, Feb. 21, 1931, pp. 223–224. Interrelation between arc and welding process, fusion and welding current, i.e., kind of current, polarity, current intensity, kind of electrodes, etc.; calculation of fusion constants; causes of failures, etc. Abstract of dissertation at Inst. of Tech. Berlin.

Machines. An Improved Arc Welding Generator, J. H. Blankenbuehler. Am. Inst. Elec. Engrs.—Advance Paper, no. 13, for mtg. Jan. 26–30, 1931, 5 pp., 8 figs. Welding operator may encounter trouble in starting arc or in having arc extinguish itself too readily; those causes of trouble which are attributed to welding generator are analyzed and explained in terms of generator design; means for eliminating generator characteristics causing these troubles, is outlined and results obtained are shown by oscillographic records.

Motor Frames. Resistance Welding of Motor Frames, N. Thomson. Am. Inst. Elec. Engrs.—Advance Paper, no. 6, Jan. 26–30, 1931, 4 pp., 11 figs Making of motor frames using rolled plate in place of castings formerly used, object being to reduce cost; method of manufacture is briefly outlined including rolling, welding, sizing, and other operations; electric resistance welding method is emphasized and results of electrical tests on equipment are outlined; oscillograph records give character of resistance flash weld in some detail; result is better product at less cost.

ELEVATORS, ELECTRIC

Control. Interlocked Elevator Control Prevents Costly Choke-Ups, R. Walter. Elec. World, vol. 97, no. 8, Feb. 21, 1931, pp. 356–359, 5 figs. Almost every conceivable contingency has been guarded against in elaborate electrical control for conveyor in handling grain at rate of 8 tons per min. in new no. 3 elevator at Fisher Flouring Mills Company in Seattle; high-speed automatic bulk handling of grain; visible signals showing all operating set-ups· automatic shut off in case of choke-up; interlocked motor control circuits prevent starting grain flow until all spouting is properly set and all machinery is in operation are featured.

ENGINEERING

History. L'Evolution et le Developpement des Principales Industries depuis Cinquante Ans, 1880–1930; Issued by Génie Civil as a special number; Paris, Jules-Lefebvre, 1930, 236 pp., illus., 25-fr. In commemoration of its 50th anniversary, "Genie Civil" has issued special number devoted to review of progress of specialists describe developments in public works, mining, agriculture, roadbuilding, railroads, etc. Publication is valuable historical summary. Eng. Soc. Lib., N. Y. (Each paper also indexed separately.)

F

FLOW OF WATER

Pipes. Expériences sur les conduites de l'usine de Mièġebat (Experiments on Power-Station Conduits), Camichel, Leclerc, du Sablon and Escande. Science et Industrie, vol. 14, no. 203, Dec. 1930, pp. 920 and 924, 1 fig.; see also brief translated abstract in Water and Water Eng., vol. 33, no. 386, Feb. 20, 1931, p. 95. Details, mode and results of investigation into flow in short lengths of pipe line at Miegebat power station of Midi Railway Co., with view to application of data obtained to similar cases greater in extent and to high Reynolds' numbers.

FOUNDRIES

Time Study. See INDUSTRIAL MANAGEMENT, Time Study.

FURNACES, ANNEALING

Bright Annealing in Hydrogen. Continuous Bright Annealing of Steels in Hydrogen, F. C. Kelley. Fuels and Furnaces, vol. 9, no. 3, Mar. 1931, pp. 303–304, 1 fig. Fundamental principles involved in continuous bright annealing of stainless irons and low-carbon steel sheets. Before Am. Inst. Min. and Met. Engrs.

G

GAGES

Measurement With. Gauging and Measuring Methods. Instn. Production Engrs.—Proc., vol. 9, no. 7, Jan. 1931, pp. 201–213. History of measures; metric system; length standard of United States; ratio of yard to meter; standards in manufacturing; internal limit gages; measurement of screw threads; angular measurement; standard taper gages; gear measuring.

Grundlagen, Mittel und Beispiele zweckmaessiger Werkstattmessverfahren (Principles, Speed and Examples of Efficient Machine Shop Measuring Methods), T. Damm. Berichte ueber betriebswissenschaftliche Arbeiten, vol. 6, 1931, 31 pp., 100 figs. Survey of fundamental principles and speed of measurement with data on use, design and accuracy of all types of gages and gaging instruments; practical examples illustrate application to ball bearings, gears, shafts, bores, frames, and crankshaft.

Optical. An Optical Coincidence Gage, I. C. Gardner and F. A. Case. U. S. Bur. Standards—Jl. Research, vol. 6, no. 2, Feb. 1931, pp. 229–237, 6 figs. Optical instrument which enables one to make measurements in direction normal to surface viewed; method of operation is sufficiently simple to permit its use for routine industrial measurements; instrument is similar to military range finder except that two telescopes forming optical system of range finder are replaced by two microscopes; magnification is approximately 95; probable error of single reading is approximately plus or minus 0.0001 mm.

Plug—Chromium Plated. The Resistance of Chromium-Plated Plug Gages to Wear, H. K Herschman. U. S. Bur. Standard—Jl. Research, vol. 6, no. 2, Feb. 1931, pp. 295–304, 5 figs. Investigation of chromium-plated plug gages with particular reference to resistance to wear was made; chromium was deposited on hardened 1.0 per cent carbon steel under varying conditions so as to produce what are commonly referred to as "bright," "milky," and "frosty" deposits; "bright" deposits were tested in both lapped and unlapped conditions; other two types were tested in lapped condition only; scratch hardness values of chromium plate produced under these varying conditions were studied.

GEARS

Lubrication. Protecting Heavy-Duty Gears by Proper Lubrication, M. Reswick. Iron Age, vol. 127, no. 11, Mar. 12, 1931, pp. 860–863 and 920, 4 figs. Action of lubricant with particular regard to problems of high tooth pressure and low speed; type of gear lubricants and their application to gear-reducer units and large rolling-mill pinions.

Speeds. Richtdrehzahlen und ihre Guenstigste Konstruktive Ausnutzung (Standardized Revolution Numbers and Their Advantageous Utilization in Design), R. Germar. Werkstattstechnik, vol. 25, no 3, Feb. 1, 1931, pp. 57–62, 19 figs. New method for laying out of gears with geometric revolution series, with particular regard to application to lathes; simplification in calculation of more difficult gear arrangements brought about by standardization of revolutions; determination of most favorable gear arrangements for specific purposes, and reference to work of G. Schlesinger.

GRINDING

Estimating. Guetesteigerung und Kostensenkung beim Schleifen (Improvement of Quality and Reduce of Cost in Grinding), Kunz. Maschinenbau, vol. 10, no. 4, Feb. 19, 1931, pp. 111–113, 3 figs. Fundamental aspects of different grinding methods for various purposes with nomographic charts for estimating grinding costs.

GRINDING MACHINES

Cams. Cam Grinding. Automobile Engr., vol. 21, no. 277, Feb. 1931, pp. 64–65, 5 figs. Design and operation of attachment introduced by Churchill Machine Tool Co. for cam-grinding machine dealing with shafts with overall lengths of up to 16 in., 31 in., 48 in., and 60 in., respectively.

Crankshafts. Two New Churchill Precision Grinding Machines for Automobile Crankshaft Pins and Crankshaft Journals. Model "DCH." Brit. Machine Tool Eng., vol. 6, no. 67, Jan.-Feb. 1931, pp. 211–216, 6 figs. Design and operation of machines equipped with hydraulic positive spacing device and hydraulic wheelhead movement.

H

HEAT TRANSMISSION

Tube to Water. The Coefficients of Heat Transfer From Tube to Water. A. Eagle and R. M. Ferguson. Instn. Mech. Engrs.—Proc., no. 4, 1930, pp. 985–1030 and (discussion) 1030–1074, 15 figs. Description of apparatus and results of tests to determine way in which coefficient of heat transfer varies with physical properties of fluids employed.

HOT-AIR HEATING

Diesel-Engine Exhaust. Direct Air Heating From Diesel Exhaust Gases. Diesel Power, vol. 9, no. 2, Feb. 1931, pp 86–87, 3 figs. Design, construction, and operating features of air heater using Diesel-engine exhaust gases for building heating offered by Nichols Products Corporation; principal advantages claimed are moderate cost and better utilization of recovered heat; method of applying Diesel engine exhaust gases to direct air heating.

HYDROELECTRIC POWER PLANTS

Automatic. Fully Automatic Hydro Power Plant, P. J. Croft, J. R. Desloover, and D. Hutchison. Can. Engr., vol. 60, no. 10, Mar. 10, 1931, pp. 11–14, 6 figs. Operation of electrical equipment at Upper Notch Plant of Northern Ontario Power Co.; equipment consists of two 48 ft. head, 6500 hp., 125 r.p.m. hydraulic turbines direct connected to two 6500-kva., 11,000-volt, 25-cycle generators; fully automatic control and switching equipment designed for possible remote control from distant supervisory plant; metal-clad switchgear; four 4500-kva., 11,000/-110,000-volt, 25-cycle transformers.

Small Automatic Plant, J. J. Traill and N. F. Seymour. Elec. News, vol. 40, no. 5, Mar. 1, 1931, pp. 35–38, 5 figs. Elliott Chute plant in South River is under discussion; storage basin has area of 730 acres at elevation 868.5 and capacity of 6200 ft. between elevations 855 and 868.5; drainage area upstream from it is 234 sq. mi.; turbine unit is built by S. Morgan Smith-Inglis Co., has single vertical runner of propeller type, rated at 1800 hp. at 327 r.p.m. under head of 39 ft.; generator is Swedish General Electric Co. vertical-type machine rated capacity of 1800 kva., 80 per cent power factor, 3-phase, 60-cycle, 2300-volt, 327 r.p.m. with direct connected 22-kw., 125-volt exciter.

Columbia, S. C. Convenient Operation Featured in Saluda Design, O. L. Hooper and J. P. Garvin. Power, vol. 73, no. 7, Feb. 17, 1931, pp. 290–293, 5 figs. Saluda hydroelectric development of Lexington Water Power Co. has four 55,650-hp., 180 ft. head units; by extensive system of remote control and signal devices practically entire operation of plant centralized under one operating head, thus eliminating mistakes due to telephone orders; turbine bearings oil-lubricated; cross-section through power house and surge tank.

Equipment. Some Outstanding Trends in Canadian Central Station Practice, D. Anderson. Elec. News, vol. 40, no. 4, Feb. 15, 1931, pp. 42–44, and 50, 5 figs. Tie bank connections were constructed for interchange of power on Southern Canada and Shawinigan systems and on East Kootenay and Calgary Power systems; 8000 ft. river crossing was built to carry power from Falls River to Prince Rupert, B. C.; welded type generators have found broad application in new plants constructed; field of propeller runners was increased to 66 ft. head; notes on metal-clad switchgear, welded and umbrella-type generators, higher head propeller runners, long-distance transmission spans.

Ireland. The Shannon Hydro-Electric Scheme. Engineering, vol. 131, no. 3396, Feb. 13, 1931, pp. 250–252, 12 figs. partly on p. 208 Hydroelectric station at Ardnacrusha on river Shannon; scheme, first part of which has been completed, comprises erection of weir at Parteen Villa; hoisting machinery for all gates is operated either electrically or by hand, and is installed in roofed gangway above weir; weir is provided with fish pass, said to be one of largest in world; gates closing intake openings are of steel plate and fitted with lattice girder stiffeners, it has been necessary to build three bridges over headrace to carry existing roads.

Pumped-Storage. Herdecke Hydraulic Storage Scheme, H. A. Sieveking. Power Engr., vol. 26, no. 299, Feb. 1931, pp. 50–55, 10 figs. Design, construction and operating characteristics of power plant operated in conjunction with Goldenberg steam station of Rheinische-Westfaelisches Electricitaetswerk A.G.; outline elevation and plan of Herdecke plant; automatic control; efficiency tests.

Sweden. A Swedish Hydro-Electric Scheme. G. Willock. Elec. Rev., vol. 108, no. 2780, Mar. 6, 1931, pp. 411–413, 6 figs. Installation at Porjus is claimed to be most northerly one in world, and second largest in Sweden; there are at present installed seven twin-cased Francis turbines and one exciter unit, i.e., one 14,000 b.hp. unit, 225 r.p.m.; two 12,500 b.hp. units, two 15,700 b.hp. units, 250 r.p.m.; and one 18,000 b.hp. unit 250 r.p.m.; exciter unit is of 525 b.hp and runs at 500 r.p.m.; all these machines operate under net head of 53 m.; four single-phase and five 3-phase alternators opreate at 4000 volts.

Vermont. Bellows Falls Hydro-Electric Developments on the Connecticut River, U. S. A. Engineering, vol. 131, nos. 3395 and 3397, Feb. 6 and 20, 1931, pp. 161–163 and 263–265, 41 figs. Feb. 6: Power-house contains three 20,000-hp. turbo-generator sets, discharging into submerged draft tubes; headgates are of Browne self-closing type, operating under head of 49 ft. over sill; power house contains three units of 17,000 kva. capacity; they are three-phase machines of 60 cycles and 6600 volts, running at 85.7 r.p.m. Feb. 20 Electric connections of station and outgoing system; from transformers current is taken to 66,000 volt and 111,000 volt switch yards, from which power is transmitted to various points of general system; salt-velocity method of measuring flow, by C. M. Allen was used in determining discharge of canal above power house at Bellows Falls. Allen's report on these tests indicates maximum efficiency of 93 per cent.

Washington. The $28,000,000 Rock Island Hydro-Electric Development. Eng. and Contracting, vol. 70, no. 2, Feb. 1931, pp. 27–31, 7 figs. Information on largest hydroelectric development west of Mississippi on Columbia

River, 13 mi. below Wenatchee, Wash.; ultimate development 252,000 hp.; length of dam will be 4400 ft.; height o.a. will be 108 ft. and piers will be 40 ft. apart; there will be ultimately ten 15,000 kw. units with water wheels of 21,000 hp.; description of coffer dams, concrete mixing plants, construction camps, power transmission lines, etc.

I

ICE PLANTS

Water Treatment. Treatment of Water for Ice Manufacture, D. Burks, Jr. Univ. Illinois—Eng. Experiment Station—Bul. no. 219, vol. 27, no. 18, Dec. 30, 1930, 114 pp., 54 figs. Contents of bulletin divided into following chapters: introduction; mechanical method for treatment of waters high in sodium bicarbonate, and chemical method applicable in decreasing total dissolved salts in case of sodium bicarbonate waters; appendixes dealing with conditions occasioning formation of opaque ice, theoretical power loss incurred in removal of core water, base-exchange action of alkaline earth zeolites, general efficiency of lime treatment, and comparative cost distribution.

INDUSTRIAL LIGHTING

High-Intensity. High-Intensity Lighting Systems for the Work-World, M. Luckiesh. Elec. World, vol. 97, no. 11, Mar. 14, 1930, p. 510. Economics now demand that really high-intensity lighting be obtained by method which we have termed "general lighting plus"; psychophysiological factors demand same kind of new system, because general lighting from bright ceilings is not satisfying when level of illumination is actually high.

INDUSTRIAL MANAGEMENT

Budget Control. Budget Control Attuned to Changing Business Conditions, S. G. Koon. Iron Age, vol. 127, no. 9, Feb. 26, 1931, pp. 698–700. Principles of comprehensive system of budget control put into effect last summer by manufacturer of electrical goods; tables show how all indirect labor and departmental expenses, including stores, equipment repairs, etc., are allocated on definite basis on direct-labor hours as ascertained monthly.

Cost Accounting. Compiling Maintenance Costs at Robert Gaylord, Inc., H. L. Bode. Soc. Indus. Engrs.—Bul., vol. 13, no. 1, Jan. 1931, pp. 17–19. Maintenance cost system used by Robert Gaylord, Inc., St. Louis, Mo., consists of budgeted costs and actual costs; classification of machines and tools; analysis of maintenance data.

Does Mass Production Tend to Minimize Profits, W. W. Hay. Iron Age, vol. 127, no. 8, Feb. 19, 1931, pp. 605–608 and 682, 3 figs. Analysis of factors controlling production costs with particular regard to automobile industry; chart shows comparison of capacity operations with manufacturing efficiency, and operation of law of diminishing returns in price trends.

Hours Saved Are Profits Gained, H. W. Benton. Factory and Indus. Mgmt., vol. 81, no. 3, Mar. 1931, pp. 415–416. Method by which foreman can effectively supervise daily expenditure of indirect labor hours.

The Value of the Standard Cost Finding System to Management, W. R. Ashe. Paper Trade Jl., vol. 92, no. 10, Mar. 5, 1931, pp. 65–67. Profitable management under adverse conditions; reason for cost system; relation of volume to equipment; relation of sales to production cost and equipment; value of system in cost and sales control; correlation of actual and used cost.

Development of. Le role de l'ingénieur dans l'organisation rationnelle due travail (The Role of the Engineer in Rational Organization of Production), C. de Fréminville. Génie Civil, 50th Anniversary Number, 1930, pp. 12–16. Review of development of scientific management and industry in United States and Europe, with special reference to work of Taylor, Ford, Fayol, and others; international congresses of scientific management.

Foundries—Time Study in. Die Stueckzeitbestimmung in den Giessereien bei Herstellung von handgeformten Gusstecken (Piece-Time Estimation in Foundries for Production of Hand-Molded Castings), G. Jandl. Giesserei, vol. 18, no. 8, Feb. 20, 1931, pp. 157–162, 18 figs. Methods of piece-work estimation in production of individual castings and in mass production; advantages and disadvantages of methods heretofore used; analysis of piece-work wages; new method of approximate calculating piece-time and piece rate based on volumetric content, surface conditions, and peculiarities of casting in question; examples of use of curves and tables; practical results with new method.

Production Control. A Proved Plan for Reducing Material and Labor Costs, H. M. Suttom. Wood Working Industries, vol. 9, no. 2, Feb. 1931, pp. 17–19 and 33 and 41, 1 fig. Plan for analyzing machine and assembly wastes and for determining allowable waste percentage.

Wirtschaftliche Losgroesse und Fabrikationszeit (Economic Lot Size and Production Time), H. Kroner. Werkstattstechnik, vol. 25, no. 4, Feb. 15, 1931, pp. 99–101, 3 figs. Mathematical investigation of relations between production cost and production time with regard to lot sizes.

Production Department. Why a Production Department, C. B. Lord, Am. Mach., vol. 74, no. 11, Mar. 12, 1931, pp. 419–422. Relations of various functions of management particularly concerning responsibility for execution of work, efficiency in utilization of materials, and efficiency in production; functioning duties of executives.

Small Plants. Small-Plant Successes—3, W. B. Greene. Factory and Indus. Mgmt., vol. 3, Mar. 1931, pp. 431–433, 4 figs. Policies which have aided in development of business are: pioneering new products rather than paralleling existing lines; standardization of one line; entire line designed to use interchangeable parts.

INDUSTRIAL PLANTS

Design. Monumental industribyggnadskonst (Monumental industrial Buildings Art), C. Lindberg. Tekniska Foereningens I Finland Foerhandlingar, vol. 50, no. 12, Dec. 1930, pp. 238–242, 12 figs. Survey of architectural trends with data on outstanding industrial buildings in principal countries.

Power Requirements. Wahl der wirtschaftlichsten Betriebskraft (Choice of Most Economic Driving Power), A. Nauck. Dinglers Polytechnisches Jl., vol. 346, no. 1, Jan. 1931, pp. 5–7. Choice between electric motor, gas, gasoline, or benzol engines for required output under and over 10 hp.

INDUSTRIAL RESEARCH

Organization for. Control of New-Product Development. Factory and Indus. Mgmt., vol. 81, no. 3, Mar. 1931, pp. 437–438 and 454. Organization for development work at Cutler-Hammer, Inc., Milwaukee, Wis., consisting of 10 engineers, mechanical laboratory, electrical testing laboratory and chemical laboratory.

INTERNAL-COMBUSTION ENGINES

Fuel Injection. Fuel Injection With Spark Ignition in an Otto-Cycle Engine, C. F. Taylor, E. S. Taylor, and G. L. Williams. Soc. Automotive Engrs.—Jl., vol. 28, no. 3, Mar. 1931, pp. 345–350 and (discussion) 350–352, 11 figs. Performance of engine having injection of fuel into inlet pipe and injection into cylinder, compared with performance obtainable with conventional carburetor; power increase by over 10 per cent with injection into cylinder, and substantially lower fuel consumption; problems of injection simpler than those of similar system for Diesel engines; discussion refers to Sandell two-cycle fuel-injection aeronautic engine, scavenged and supercharged from Roots-type blower.

Ignition. Spark Timing Control Actuated by Pressure in Engine Cylinder, P. M. Heldt. Automotive Industries, vol. 64, no. 7, Feb. 14, 1931, pp. 222–224, 3 figs. Operating principles and mechanical layout of ignition and carburetor control developed by Warren F. Stanton of Pawtucket, R. I.; new system designed to compensate for all factors which delay rise in gaseous pressure.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; MOTOR-TRUCK ENGINES; OIL ENGINES.]

IRON AND STEEL

Metallurgy. The Carbon-Oxygen Equilibrium in Liquid Iron, H. C. Vacher and E. H. Hamilton. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 409, for mtg. Feb. 1931, 13 pp., 2 figs. Attempt is made to determine value of carbon-oxygen product over wide range of concentrations; in earlier stages of work, values of 0.0066 at 1580 deg. cent. and 0.0055 at 1600 deg. cent., were obtained for carbon-oxygen product; these results were obtained by selection of values; variation was great; subsequent experiments, under better control produced value of 0.0025 for product of concentrations of carbon and oxygen in liquid iron at 1620 deg. cent. and 1 atmos. pressure. Bibliography.

IRON AND STEEL PLANTS

Photoelectric Control. Photoleectric Control for Soaking-Pit Covers, R. M. Bayle. Elec. World, vol. 97, no. 9, Feb. 28, 1931, p. 409. For new mill in Middle West, Westinghouse Electric & Manufacturing Company is supplying new design of soaking pit control, making use of light sensitive relay as initiating source; in this installation layout consists of two soaking-pit cranes operating on common runway and each spanning two pits; there are seven rows, making total of 14 pits.

L

LATHES

German Designs. Die Drehbank in ihrer neuesten Gestalt und Ausblicke fuer die Weiterentwicklung (Latest Development in Lathe Design and Possibilities of Further Progress), O. Lich. Maschinenkonstrukteur, vol. 64, no. 3, Feb. 10, 1931 (supp.), pp. 21–24, 7 figs. Design of typical German makes with particular regard to arrangement of change gears, including lathes built by Schuchardt and Schuette A.-G., and Loewe.

LOCOMOTIVES

Diesel-Electric. The Diesel-Electric Locomotive, S. T. Dodd. Gen. Elec. Rev., vol. 34, no. 3, Mar. 1931, pp. 189–192. General summary of present extent of application of Diesel-electric locomotive to railroad transportation, results that have been arrived at, and what development of this application may be expected in future; characteristics; operating costs.

Diesel, Switching. 100 H. P. Oil-Engined Locomotive. Engineer, vol. 151, no. 3918, Feb. 13, 1931, pp. 180–181, 3 figs. Engine is one of two being supplied to Central Argentine Railway by D. Wickham and Co.; outstanding features are that it is driven by heavy-oil engine, of McLaren-Benz type, that it has novel change-speed gear box and that axles are of full-floating type.

Electric. A.C.-D.C. Passenger Locomotives for the New York, New Haven & Hartford Railroad, A. E. Smith. Gen. Elec. Rev., vol. 34, no. 3, Mar. 1931, pp. 200–206, 7 figs. Operating conditions; table of ratings; principal dimensions and weights; air brakes; traction motors; simplified connection diagrams and control circuit charts; auxiliary motors; compressors; control; accessories.

Design for a Passenger Locomotive for the Cleveland Union Terminal Company, B. S. Cain. Gen. Elec. Rev., vol. 34, no. 3, Mar. 1931, pp. 180–188, 15 figs. System covers 17 route mi. and contains about 60 mi. of track; system selected is 3000 volts d.c. power is obtained from two automatically controlled substations; locomotive equipment was designed for road and switching service of passenger trains; notes on design procedure from operating conditions and characteristics and testing.

Progress in Motive Power for Transportation, H. L. Andrews. Gen. Elec. Rev., vol. 34, no. 3, Mar. 1931, p. 148, 1 fig. Advances in capacity of electric motive equipment have been made possible by increasing output per pound of electrical equipment and advances made in high-speed switching and conversion equipment; that General Electric Company is one of principal contributors to advancement in transportation art is well evidenced by its many contributions to industry for both rail and railless transportation.

The Bo Plus Bo Locomotives for the Vascongados Railway, T. Boveri. Brown Boveri Rev., vol. 18, no. 2, Feb. 1931, pp. 99–102, 12 figs., some on supp. sheet. 1500 volt d.c. equipment on account of sharp curves is designed with two bogies; total weight of each locomotive is 45 to 46 tons, i.e., about 11 to 11.5 tons per axle; wheelbase of each bogie is 2400 mm. and distance between bogie is 2400 mm. and distance between bogie pivots 5200 mm.; length over buffers is 11,220 mm. and diam. of driving wheels 1000 mm.; each driving axle is driven by force-cooled motor of 141 kw.

Passenger (Pacific). Pacific 4-6-2 Types on the New Jersey Central. Ry. Age, vol. 90, no. 8, Feb. 21, 1931, pp. 413–414, 1 fig. Used for handling heavy suburban and fast passenger trains such as "Bullet" and "Blue Comet;" boiler details; cylinders 26 by 28 in.; driving wheels, 74 in.; steam pressure 240 lb. per sq. in.; maximum tractive force 52,180 lb.; total engine weight 333,830 lb.; total engine wheelbase 36 ft. 9 in.

Testing. Tests of Mikado-Type Locomotive Equipped With Nicholson Thermic Syphons, E. G. Schmidt, E. G. Young, and H. J. Schrader. Univ. Illinois—Eng. Experiment Station—Bul. no. 220, vol. 28, no. 23, Feb. 3, 1931, 102 pp., 20 figs. partly on supp. plate. Design and operation characteristics of locomotive and siphons; test program and procedure, boiler performance and test results; appendixes dealing with test-procedure methods employed and tabulated results.

LUBRICANTS

Oiliness. Oiliness in Lubricants Is Function of Their Surface Tension, L. R. Taylor. Nat. Petroleum News, vol. 23, no. 5, Feb. 4, 1931, pp. 63 and 65, 3 figs. Just what oiliness is, in lubricants, has never been satisfactorily explained; efficiency of lubricating oil involves maintaining proper film between moving surfaces; properties of lubricant which influence it's character as lubricant are viscosity, density. capillarity, or surface tension compressibility, and tensile strength; capillary effects do play fundamental part in lubrication, and oiliness is function of surface tension. Bibliography.

Testing. Die Pruefung der Schniermittel (Testing of Lubricants). Montanistische Rundschau, vol. 23, no. 2, Jan. 16, 1931, pp. 3–9. Abstract from report of committee of Deutscher Verband fuer die Materialpruefungen der Technik (German Society for Testing Materials), no. 8, containing critical discussions of specifications for testing lubricants.

LUBRICATION

Bearings. Anomale Geschwindigkeitsverteilung in duennen Schmierschichten (Anomalous Velocity Distribution in Thin Lubricating Films), H. Umstaetter. Kolloid Zeit., vol. 54, no. 2, Feb. 1931. pp. 220–226, 4 figs. Report on theoretical and experimental study of hydrodynamic theory of bearing friction, made at Darmstadt Institute of Technology; relationship between viscosity, molar weight, temperature, and form of molecule.

M

MACHINE DESIGN

Safety Factors. Sikkerhedskoefficient—Sikkerhed (Safety Coefficients—Safety), H. H. Dahlerup-Petersen. Ingenioren, vol. 40, no 6, Feb. 7, 1931, pp. 65–70, 4 figs. Consideration of materials properties in machine design with particular regard to parts subjected to variable loads; reference to resonance phenomena in crankshaft of internal-combustion engine.

MACHINERY

Dynamics of. Dynamical Analysis of Machines, R. Eksergian. Franklin Inst.—Jl., vol. 212, no. 3, Mar. 1931, pp. 353–366, 7 figs. Analysis of mechanisms subjected to common rotation; oscillation of synchronous machine connected with engine mechanism; torsional oscillations in engine shafts; time vector analysis of torsional oscillations.

Exhibitions—Leipzig. The Great Engineering and Building Fair, Leipzig, March 1 to 11, F. Isermann. Eng. Progress, vol. 12, no. 2, Feb. 1931, pp. 25–48, 56 figs. Description of few special machines to be shown at Leipzig fair, which will occupy 17 halls and 33 acres; there will be 2300 exhibitors from 30 branches of machinery industry.

MATERIALS HANDLING

Construction Industry. Improvements in Handling Building Material, G. G. Wheat. Civil Eng. (N. Y.), vol. 1, no. 6, Mar 1931, pp. 484–488, 20 figs. Methods developed for handling building materials; modern mechanical handling of brick; shipping tile in steel crates; handling masonry units on job; industrial railroads in Empire State Building; transporting bulk cement; tubular steel tower hoists.

METALS

Cutting. Wirtschaftlichkeit bei Dreh-, Hobel, und Stossarbeiten (Efficient Utilization of Lathes, Planers, and Shaping Machines), W. Fehse. Maschinenbau, vol. 10, no. 4, Feb. 19, 1931, pp. 114–117, 1 fig. Important factors relating to improvement of quality and reduction of production costs with particular regard to utilization of cooperation and technical literature; examples illustrate advantages of special tool steels and hydraulic drive.

Wirtschaftliches Bohren und Fraesen (Economical Drilling and Milling), H. J. Stoewer. Maschinenbau, vol. 10, no. 4, Feb. 19, 1931, pp. 117–119, 5 figs. Advantages obtained by use of proper materials for cutting tools, design of tool and machine, care of tools, standardization, etc.; reference to principal research work.

Cutting—Alloy Tools. The New Alloys and Machine Tool Design—II and III, F. W. Shaw. Metallurgia, vol. 3, nos. 15 and 16, Jan. 1931, pp. 91–93 and 96, Feb., pp. 131–134, 17 figs. Jan.: Cutting tools; reduction of cut-time with use of modern cutting materials is only part of high-production problem; reduction of non-cut-time is problem of at least equal importance. Feb.: Factors that control output; analysis of factors that build up non-cut-time and production time; effect of multiple tools and distribution of total time on large work; high power milling cutters are considered.

Cutting Speeds. The Probable Speed of Machining, A. H. Rodrick. Am. Mach., vol 74, no. 8, Feb. 19, 1931, pp. 307–311, 6 figs. Principles of feeds and speeds, with their dependence on materials, tools, and cutting lubricants; determination of basic cutting practice for all standard materials by means of nomographic chart which is readily adaptable to working conditions and materials.

Deformation. Zur Deutung der Deformationstexturen von Metallen (Deformation Textures of Metals), W. Boas and E. Schmid. Zeit. fuer Technische Physik, vol. 12, no. 2, 1931, pp. 71–75, 4 figs. Tests made at Kaiser-Wilhelm Institute fuer Metallforschung on nature of strains produced by tensile, upsetting, and rolling stresses.

Properties. Einige Bemerkungen ueber die Wahl der zulaessigen Anstrengung der Werkstoffe (Remarks on Selection of Permissible Stress of Materials), O. Graf. Maschinenbau, vol. 10, no. 3, Feb. 5, 1931, pp. 84–85, 3 figs. Results of tests on fatigue of steel with particular regard to effect of rolling-mill skin and drilled hole.

Zulaessige Spannungen der im Maschinenbau verwendeten Werkstoffe (Allowable Stresses of Materials for Machinery Construction), E. Bock. Maschinenbau, vol. 10, no. 3, Feb. 1931, pp. 66–83, 24 figs. Opinions of principal German authorities regarding relative importance of factors determining permissable stresses in machine design; data on strength properties of various metals and stress distribution in machine elements

Structure. Texture of Metals After Cold Deformation, F. Wever. Am. Inst. Min. and Met. Engrs.—Preprint for mtg., Feb. 1931, 25 pp., 33 figs. Résumé of earlier investigations with X-ray; camera apparatus for reflection projection; texture of cold-deformed metals; résumé of study of cubic metals; texture of cold-compressed metals and of cold rolled metals; texture with plane parallelepipedal compression; analysis of textures; deformation texture; body-centered cubic metals; correlation with rolling process. Bibliography.

Testing. A Simple Method of Studying the Stress-Strain Relation in the Notched-Bar Impact Test, T. Kawai. Tohoku Imperial Univ.—Sci. Reports, vol. 19, no. 6, Dec. 1930, pp. 727–743, 12 figs. Method for determining energy-strain and stress-strain relation in notched-bar impact test, by using ordinary Charpy machine; from net absorbed-energy-bending relation in impact test, stress-bending relation was obtained be evaluating tangent at each point on curve representing former relation. (In English.)

Wear. Abnutzung von Metallen unter besonderer Beruecksichtigung der Messflaechen von Lehren (Wear of Metals With Particular Regard to Measuring Surfaces of Gages), O. Nieberding. Berichte ueber Betriebswissenschaftliche Arbeiten, no. 5, 1930, 26 pp., 35 figs. Design and operation of wear-testing apparatus with results illustrating relation between wear and path of friction, load, hardness, for different types of iron and steel.

MOTOR-TRUCK ENGINES

Heavy-Oil. Oil Engines on Motor Truck Exhibition (Die Lastwagenschau im Zeichen des Oelmotors), E. Aster. Automobiltechnische Zeit., vol. 34, no. 5–6, Feb. 25–28, 1931, pp. 127–130, 16 figs. Illustration of operating principles of various makes including MAN, Junkers, Linke-Hofmann-Busch, Acro (Bosch), MWM, Caimler-Benz, Deutz, Koerting, Buessing Hanomag, Lanz, Hesselman, and Krupp; Table gives specifications and performance data on principle exhibits representing Diesel and other oil engines.

Producer-Gas. L'alimentation au gasoil des moteurs d'automobiles d'après le procédé de M. Chilowsky (Operation of Automobile Engines by Means of Gas Oil According to Method of Chilowsky), M. Laurence. Industrie des Voies Ferrées et des Transports Automobiles, vol. 25, no. 289, Jan. 1931, pp. 8–14, 3 figs. Results of experiments with method based on generation of gas by partial combustion of gas oil; sketches illustrate details of carburetor and generating chamber as mounted on motor truck; saving in operating expenses amounting to 60 per cent.

O

OIL ENGINES

Automotive. New Automotive Oil Engine Claimed to Operate With Accelerated Combustion. Diesel Power, vol. 9, no. 2, Feb. 1931, p. 76, 2 figs. Oil engine of high specific capacity based on combustion system with novel features developed to commercial stage by F. Oberhaenslie and Cie. and is now being used for powering "Vomag" motor trucks of Vogtlaendische Maschinenfabrik; engine operates at 1350 r.p.m., normally develops 80 b.hp. in four cylinders with maximum overload capacity of 100 b.hp.; cylinders 5.118 by 7.087 in.; engine weight 1233 lb.

Railroads. The Oil Engine and the Railways, C. J. Hyde Trutch. Inst. Transport—Jl., vol. 12, no. 4, Feb. 1931, pp. 170–194 and (discussion) 194–204, 13 figs. Present state of development of engines and transmission; factors affecting economic comparison between steam, electric, and oil-electric working and general estimate of savings to be made in Great Britain; suburban, secondary passenger, lightly used lines switching and main line traffic.

OPEN-HEARTH FURNACES

Operating Difficulties. Overcoming Certain Operating Troubles in Making Open-Hearth Steel, T. N. Armstrong. Iron Age, vol. 127, no. 11, Mar. 12, 1931, pp. 864–867. Consideration of relationship between characteristics of lime used in open-hearth charge and ratio between pig iron and steel scrap; where burnt lime is employed much larger proportion of scrap can be used; troubles connected with use of southern grades of pig iron.

Regenerators. Die Berechnung der Waermespeicher (Calculation of a Regenerator), K. Rummel. Archiv feur das Eisenhuettenwesen, vol. 4, no. 8, Feb. 1931, pp. 367–374, 5 figs. Method of regenerator calculation is developed and example given of open-hearth furnace: influence of gas-air-temperature curve.

P

PACKING MACHINES

Design. Zur Getriebetechnik der Verpack-Maschinen (Kinematics of Packing Machines), H. Alt. V.D.I. Zeit., vol. 75, no. 9, Feb. 28, 1931, pp. 245–254, 45 figs. Theoretical analysis of various kinematic and design problems together with practical application to candy-packing machines; comparison of link and cam drives.

PHOTOELASTICITY

Stress Analysis. Optical Stress Analysis, L. Tuzi. Engineering, vol. 131, nos. 3393 and 3396, Jan. 23, 1931, pp. 116–117, and Feb. 13, pp. 193–196, 23 figs. Review of two theses published in Institute of Physical and Chemical Research—Scientific Papers, Tokyo, entitled Development of Experimental Methods in Photoelasticity, and Photoelastic Study of Stress in Side Framing of Steel Car; author discusses in first of papers conditions in which bands disappear as stress is increased; four typical cases are represented; method of analysis is applied to determining stresses in side framing of one of steel-truck cars used in Japanese railways.

PISTON RINGS

Manufacture. Neue Untersuchungen ueber den Guetegrad von Kolbenringen in Abhaengigkeit vom Herstellungsverfahren (Effect of Manufacturing Process on Quality of Piston Rings), N. Stern. Automobiltechnische Zeit., vol. 34, no. 4, Feb. 14, 1931, pp. 89–93, 14 figs. Data on relative advantages of various manufacturing methods; table gives physical properties, radial pressure, etc., for different types of rings.

PLASTICS

Molded Parts. Molded Parts of Cellulose Acetate, J. F. Walsh. Product Eng., vol. 2, no. 2, Feb. 1931, pp. 72–73, 2 figs. Unlimited color range and effects, permanent luster, strength, and resilience obtainable in products molded or veneered with this plastic material; average physical and chemical properties of cellulose-acetate molding material.

POWER GENERATION

Progress in. L'evolution des machines thermiques, de 1880–1930 (Evolution of Heat Engines from 1880–1930), C. Monteil. Génie Civil, 50th Anniversary No., Nov. 1930, pp. 175–183, 11 figs. Progress in design and performance of boilers, steam engines, steam turbines and Diesel engines; sketches illustrate typical makes including Sulzer, Borsig, Escher, Wyss, Allgemeine Elektricitaets Gesellschaft, Rateau, M.A.N.

PUMPS, CENTRIFUGAL

Anti-Friction Bearings. Anti-Friction Bearings for Centrifugal Pumps—2, E. L. Maag. Power House, vol. 25, no. 2, Feb. 1931, pp. 54–

56, and 72, 6 figs. Design and constructional features of various types of bearings; bearings and lubrication.

Curves. Centrifugal Pumps, F. Johnstone Taylor. Water and Water Eng., vol. 33, no. 386, Feb. 20, 1931, pp. 55–57, 3 figs. Curves and their interpretation; non-overloading pumps; over-loading pumps; prime movers; problem of speed.

Feedwater. Die Speisewasserregelung bei Elektro- und bei Turbo-Kesselspeisepumpen (Feedwater Control in Electric and Turbine Driven Feedwater Pumps), H. Kissinger. V.D.I. Zeit., vol. 75, no. 7, Feb. 14, 1931, pp. 191–194, 7 figs. Interpretation of operations in controlling of feedwater supply for boilers; graphs illustrate relations between output of pumps, boiler pressure, etc.

Submerged-Motor. Die Wernert-Tauchpumpe (The Wernert Submerged Motor Pump), W. Benedict. V.D.I. Zeit., vol. 75, no. 8, Feb. 21, 1931, pp. 225–227, 6 figs. Detailed description of improved submerged motor pump for deep water wells; efficiency increased by using normal motors and special form for centrifugal pump runner blades; test results showing efficiency as high as 80.3 per cent.

RAIL MOTOR CARS

Gasoline-Electric. The Steam Branch Lines Go Gas-Electric, F. L. Sahlmann. Gen. Elec. Rev., vol. 34, no. 3, Mar. 1931, pp. 197–199, 5 figs. It is shown with examples and data that gas-electric car is filling important field in branch line service and tells what economies are secured by its use.

Propeller-Driven. A Propeller-Drive Quick-Travelling Railway Car. World Power, vol. 15, no. 86, Feb. 1931, pp. 124 and 126, 1 fig. Principal drive of light, stream-lined rail car is six-cylinder internal-combustion engine of 500 hp.; full speed of 93.2 m.p.h. in still air claimed with 200 hp., leaving ample margin for head winds; fuel consumption 50 liters per 100 km., accommodations for 40 passengers; German State railway authorities are not directly taking part in development of this car, but have shown keen interest and have provided stretch of railway on which experimental tests have been carried out.

Steam. "Sentinel-Cammell" Gear-Driven Steam Rail Coach, Axholme Joint Railway. Ry. Gaz., vol. 54, no. 6, Feb. 6, 1931, p. 202, 1 fig. Design and construction features; gear-driven steam rail car which has been introduced on Axholme line, between Goole and Haxey, which is jointly owned by L.N.E. and L.M.S. Railways; list of principal dimensions.

Two-Engines. Erie Rail Car Equipped With Two 300-hp. Engines, E. H. Peters and I. R. Cummings. Ry. Age, vol. 90, no. 8, Feb. 21, 1931, pp. 415–416, 3 figs. First installation of double power plant; car to be used in mainline service between Youngstown, Ohio, and Dayton, Ohio; engines and auxiliaries; electrical equipment; brakes and heating plant; floor plan, principal weights, dimensions, and operating data of Erie oil-electric rail car.

R

RAILROAD SIGNALS

Remote-Control. Remote Control of Switches and Signals, J. Parsons. Inst. Transport— Jl., vol. 12, no. 3, Jan. 1931, pp. 139–143. Electric switch machine, also machine with dual control selector; signals; typical examples of signal operation; automatic control of train movements; installations in Argentine.

REAMERS

Tolerances. Practical Hole Tolerances, D. W. Ovaitt. Am. Mach., vol. 74, no. 8, Feb. 19, 1931, pp. 316–317, 4 figs. Review of principal tolerance systems with particular regard to merits of system adopted by General Motors Engineering Standards Committee.

ROLLING MILLS

Bearings. New Designs of Rolling Mill Bearings, H. Weinlig. Blast Furnace and Steel Plant, vol. 19, no. 3, Mar. 1931, pp. 402–405, 9 figs. Latest German developments in bearings and their lubrication with data on roll bearing with adjoining chambers for reversing mills; wearing resistance of lignum vitae. Before Assn. German Iron and Steel Engrs.

Roll Pressures. Measurement of Rolling Mill Pressures, W. L. De Laney. Iron Age, vol. 127, no. 8, Feb. 19, 1931, pp. 609–611, 6 figs. Design and operation of gage inserted between upper roll neck and screwdown, and use of McCollum-Peters electric telemeter; oscillograph record of rolling pressures and times.

ROLLS

Cast-Iron. Fatigue Stresses, With Special Reference to the Breakage of Rolls, F. Bacon. Engineering, vol. 131, nos. 3397 and 3399, Feb. 20, 1931, pp. 280–282 and Mar 6, pp. 341–344, 6 figs. Laboratory fatigue tests; fatigue properties of cast irons; fatigue stresses in bottom roll; fatigue failure of laterally loaded shaft; hair cracks in fatigue fractures; classification of fatigue fractures according to hair crack contours; transverse bending of cast iron: influence of roll diameter on breakage; influence of depth of chill; running strength of rolls. Before S. Wales Inst. Engrs.

S

SEAPLANES

Catapults for. Catapult Launching for Aeroplanes. Aeroplane, vol. 40, no. 8, Feb. 25, 1931 (supp.) pp. 327–328, 330 and 332, 6 figs. Design and operation of Mactaggart Scott catapults for Royal Navy launching airplanes weighing up to 8000 lb.; diagrams illustrate arrangement of power cylinder and reeving of accelerating rope.

SHEET-METAL WORKING

Forming Tests. Forming Properties of Thin Sheets of Some Nonferrous Metals, W. A. Straw, M. D. Helfrick, and C. R. Fischrupp. Am. Inst. Min. and Met. Engrs.—Tech. Pub. 406, for mtg. Feb. 1931, 14 pp., 4 figs. Data on forming tests, to show minimum radii of 90 deg. forming tools that produce acceptable bends in some thicknesses and tempers of some brass, phosphor bronze and nickel silver sheet; numerical relationship between thickness of sheet and radius of tools is not attempted; experience in application of data has demonstrated practicability of using them in designing formed parts and forming tools.

SPRINGS

Helical. The Calculation of Helical Springs of Round Wire, E. Honegger. Brown Boveri Rev., vol. 18, no. 3, Mar. 1931, pp. 120–125, 7 figs. Simplified method of calculation; development of equations; examples of application; assumptions; deduction of most important formulae.

Testing Steel for. An investigation of Steels for Aircraft Engine Valve Springs, A. Swan, H. Sutton and W. D. Douglas. Engineering, vol. 131, no. 3398, Feb. 27, 1931, pp. 314–316, 9 figs. Apparatus was designed by Savage, of Royal Aircraft Establishment, in which one or more springs operated by cam could be studied stroboscopically, and exact coil movements and positions during rise and fall of cam recorded to magnified scale; it is not intended to deal in detail with results obtained from these experiments, but only to consider broad conclusions as affecting spring failures. Before Instn. Mech. Engrs.

STEAM

Air-Steam Mixtures. The Properties of an Air-Steam Mixture as a Working Substance, J. Small. Instn. Engrs. and Shipbldrs. in Scotland —Trans., vol. 73, 1929–30, pp. 228–280, 13 figs. Mixtures of ideal gases; principles adopted for air-steam mixtures; methods of mixing; performance of mixtures; application of gas-steam mixtures.

STEAM ACCUMULATORS

Paper-Mill Installation. The Steam Accumulator in the Board Mill, N. H. Sandberg. Paper Trade Jl., vol. 92, no. 8, Feb. 19, 1931, pp. 103–105, 5 figs. Heat-balance diagram of Waldorf Paper Products Company's high-pressure plant; advantages of accumulator in plant operation; stabilization of process steam pressure; elimination of stand-by power. Before Tech. Assn. Pulp and Paper Industry.

STEAM-ELECTRIC POWER PLANTS

Air Pollution. Fulham Generating Stations. Engineer, vol. 151, no. 3920, Feb. 27, 1931, pp. 234–235. Results of inquiry into application made by Metropolitan Borough Council of Fulham for consent to extension of Borough Council's power station; terms of conditions imposed on Borough Council in respect of construction and operation of station, deal specifically with elimination of smoke and grit, removal of oxides of sulphur, keeping of records, and inspection and testing of works; Council proposes to erect up-to-date station, first section of which will contain two 60,000-kw. and two 6000-kw. turbo-alternators. From statement issued by Electricity Commissioners.

Berlin. Die Bauanlagen des Gross-Kraftwerkes West der Berliner Staedtischen Elektrizitaetswerke Akt.-Ges. (Construction of the West Power Plant of the Berliner Staedtische Elektrizitaetswerke Akt.-Ges.), K. Bernhard. V.D.I. Zeit., vol. 75, no. 9, Feb. 28, 1931, pp. 255–258, 13 figs. Report on testing of foundation sites and construction of deep pile and concrete foundations for boiler house and other structures; design and construction of structures for supply of coal and water and for removal of ashes.

Cleveland. Ashtabula, Cleveland's Newest Generating Center. Elec. World, vol. 97, no. 11, Mar. 14, 1931, pp. 504–507, 13 figs. Station went on line in November, 1930, with three 50,000-kw. turbo-generators; except for increase of size station is duplicate of Avon, which has proved itself eminently satisfactory operator; energy goes out from Ashtabula on 132-kv. lines, 8 mi. to 30,000-kva. substation and 53 mi. to 54,000 kva. substation; turbo-generators of 17 stages operate on 375 lb. steam 700–725 deg. fahr., and generate at 13,200 volts.

High-Pressure. The Saskatoon Power Station, F. H. Fullerton. Elec. Rev., vol. 108, no. 2778, Feb. 20, 1931, pp. 316–317, 5 figs. Initial installation of new plant includes one Parsons 10,000-kw., 3600-r.p.m. turbo-alternator; 75-kw. station auxiliary turbo alternator, and two Stirling-type boilers equipped with superheaters, forced-draft gear, chain-grate stokers, and air preheaters; steam conditions at boiler stop valves are 400 lb. per sq. in. and 735 deg. fahr. electrical generation is at 13,200 volts, 3-phase, 60 cycles.

Peak-Load. The Advantage of Large Overload Capacity in Central Stations, G. Stoney. Engineering, vol. 131, no. 3396, Feb. 13, 1931, p. 193. Reference is made to paper by I. V. Robinson, before World Engineering Congress, Tokyo, 1929, and paper by C. A. Parson and R. Dowson, at World Power Conference, Berlin, 1930, discussing value of plant with large overload capacity in central stations, by adoption of turbines with large overload capacity, capital cost can be greatly reduced at small increase in fuel consumption, with further advantages of reduced attendance and facilities for dealing with sudden increase of load due to fog or breakdown.

Stand-By. Spitzendeckung in Elektrizitaetswerken durch Ruthsspeicher (Peak-Load Supply of Electric Power Plants With Ruth's Accumulators), E. Praetorius. Elektrotechnik und Maschinenbau, vol. 49, no. 8, Feb. 22, 1931, pp. 143–150, 9 figs. Load analysis on basis of load curves of typical plants; requirements of peak supply plant; Ruth's accumulator as equipment for peak stand-by; initial installation costs; operating experience; economic load distribution.

STEAM POWER PLANTS

Efficiency. Hoechstdruck und Zwischenueberhitzung oder Hoechste Dampftemperaturen (Superpressure and Intermediate Superheating or Maximum Temperatures), W. Kaiser. Feuerungstecknik, vol. 19, no. 1, Jan. 15, 1931, pp. 6–8, 1 fig. Results of investigation based on 28 examples to determine influence of initial steam pressure, initial temperature, intermediate superheating and feedwater bleeder preheating on thermal efficiency of steam plants.

High-Pressure. Die Wirtschaftlichkeit der Hochdruck-Vorschaltanlage (Economy of High Pressure Additional Boiler Equipment), H. Schulze. Elektrotechnische Zeit., vol. 52, no. 8, Feb. 19, 1931, pp. 233–235, 2 figs. By introducing of high-pressure steam generators in extension of existing intermediate pressure plants, considerable boiler heating surface is set free, for which no application is at hand; it is shown for what conditions, depending on fuel price and working time, yet additional high-pressure equipment is economically superior to extension of intermediate pressure installations.

Researches on High-Pressure Steam in Czechoslovakia and the Economical Outlook for High-Pressure Plants, J. Havlicek. Engineering, vol. 131, no. 3398, Feb. 27, 1931, pp. 311–313, 5 figs. Results of tests at plant installed for making measurements of total heat of steam at pressures up to and over critical pressure and temperatures up to 500 deg. cent.; upper limit for steam temperature is to be found at about 550 deg. with steel superheaters; in possible increases of superheat above this limit, serious consideration must be given to dissociation of water vapor due to passing over hot tube surfaces. Before World Power Conference, Berlin.

The Paraffine Companies, Inc., Balance Power and Steam With Variable-Effect Evaporators, H. J. Byrne. Power, vol. 73, no. 7, Feb. 17, 1931, pp. 282–287, 6 figs. Industrial power plant unique in layout and operating method has been built for Paraffine Companies, Inc.; operation of evaporators single, double, or triple effect helps balance power and steam loads; power-plant